MEMOIRS

OF THE

AMERICAN ACADEMY

OF

ARTS AND SCIENCES.

NEW SERIES.

VOL. VIII.—PART I.

Mo. Bot. Garden,
1897.

CAMBRIDGE AND BOSTON:
WELCH, BIGELOW, AND COMPANY,
PRINTERS TO THE UNIVERSITY.
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MEMOIRS

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AMERICAN ACADEMY.

An unpublished Grammatical Fragment.— Petronius Arbiter De Antiquis Dictionibus.

By CHARLES BECK.

Communicated September 13th, 1859.

While engaged in Europe in a search after manuscripts of the Satyricon of Petronius Arbiter, I found, in November, 1858, in the Biblioteca Riccardiana at Florence, a quarto volume of about two hundred pages containing, among other works, as *Priscianus de Ponderibus*, *Fulgentius*, *Homeri Vita*, *Francisci Petrarchi Testamentum*, also a grammatical fragment entitled *Ex Petronio Arbitro.* On the inside of the cover is this statement: "Membranæ fragmentum inferius appositum ex veteri attrito tegumento huc translatum est die 19 Julii, 1776." It is, therefore, a modern copy of an older manuscript, which, from age or use, was in danger of becoming illegible, or being altogether lost. I copied the fragment, although it was apparent that it had no connection with the Satyricon, and owed the author's name probably to some mistake or accident.* When, a few weeks later, in the pursuit of my object, I obtained, through the kind aid of the American Minister, Mr. Stockton, access to the Vatican Library, and, through the kindness of the Prince Buoncompagni, the numbers of two manuscripts bearing the name of Petronius, I found that one of them contained the same fragment which I had copied in Florence. Of this, too, I made a careful copy. While

* Those familiar with manuscripts know that they often contain works of different authors. It is possible that, in an earlier manuscript, this fragment followed the Satyricon of Petronius, and being without the name of an author, or at least without the second name Arbiter, an ignorant or careless copyist ascribed the fragment to the author of the preceding Satyricon.

in Italy, I had neither the time nor means to ascertain whether the fragment was already published, but upon a somewhat more careful investigation since my return, I have come to the conclusion that it is an ἀνέκδοτον.* The contents, although of no great importance, are yet of sufficient interest to justify the publication of the fragment. The copy of the two manuscripts will be followed by some remarks, and an attempt at a reconstruction of the text. I shall, for convenience' sake, retain the name Petronius.

Biblioteca Vaticana.

Petronius Arbiter de Antiquis Dictionibus.

Nitrum dicitur a nitra prouincia: ubi si estate prolixa pluuia terram infuderit: rapida ui solis aquam concoquit in petram salis et niui simillimam sed nihil frigoris uel salsi humoris habentem que salis uel caumate durescit uel pluuioso aere liquescit. hoc indigene ad lauandum utuntur.

Kyrogrillus animal non maius ericio simile muri uel urso in cauernis petrarum habitans in Italia abundans.

Caparis herba que fallitur. plautus in Gurgulione. Ne oliuas aut pulpamentum aut caparum. et alibi Caparis et putri cepas allece natantes.

Hepicima laus de uictoria.

Exedre thalami seu cellule seu potius cubilia aut sedes. Cicero de oratore. In eadem exedra.

Scalptura quod usitatius scalpturam dicimus: tunc histriaca dicitur: quod qui historias uel gesta aliqua exprimunt histriones.

Biblioteca Riccardiana.

Ex petronio Arbitro Fragmentum incipit.

Nitrum dicitur a nitra prouincia: ubi si in aestate pluuia terram infuderit rapida ui solis aquam concoquit in petram sali ex riuis simillimam: sed nihil frigoris uel salsi humoris habentem: quae salis more uel caumate durescit: uel pluuioso aere liquescit. hoc indigenae ad laudandum utuntur.

Cyrogrillus animal non maius ericio simile muri et urso in cauernis petrarum habitans in italia abundans.

Caparis herba que salitur. Plautus in curgulione voltis ne oliuam aut pulpumentum aut caparim: et martialis Caparim alibi et putri cepas alece natantes.

Epirima laus de uictoria.

Exedrae thalami seu cellulae seu potius cubilia aut sedes. et actoris nomen acceperunt. Cicero in eadem exedra.

Scalptura quod usitatius sculpturam dicimus tunc histriaca dicitur tam historias uel gesta aliqua exprimunt histriones.

* The only indication which I find that the contents of the fragment, or a part of them, were previously known, is contained in C. G. Anton's edition of the Satyricon, 1781, p. 490, where he gives among the Fragments of Petronius the following: "Petronii Grammatici Fragmenta. Horatius: Quis te redonavit Quiritem diis patriis? cuius nominativus est hic Quirites. — Classica a calando, id est vocando." To this is added the note: "Classica. Daniel. invenit in vet. Cod. in explicatione *classicum* haec ita expressa: et classica auctore Petronio a calando," etc.

Mulsum uinum melle decoctum. Plautus in Asinaria et cantaro mulsum date.

Peribolus templi est ipsius circumposita munitionum constructio.

Coloquintis agrestis cucurbita et uehementer amara: que more cucurbite per terram flagella defundit. Foliorum uero et fructus usualis instar cucumeris. Rotunditas coloquintis nomen indicit.

Classica sunt cornua: que conuocandi causa facta erant: et a calando id est uocando dicta. Virgilius. classica iamque sonant.

Sinaxis concilium uel auditorium uel hora conueniendi dici potest.

Amagliffi celature.

Musach sababi arca: ubi reges templum ingressuri elemosinam imponebant.

Carpasinus color est aureus sicut et citrinus.

Lurica seu cancellus est murus cenaculorum seu quorunlibet edificiorum oram ambiens ab iniuria lapsus inibi defendens.

Reuma est eruptio uel fluor.

Scutra sunt uasa aenea equalia in fundo et ore late ad calefaciendum uinum.

Amule uero ad offerendum uinum uasa enea esse dicuntur.

Catalogus ordinarius sermo.

Auarus quasi auidus eris. est littera in iunctura detracta uel forsitan simplex deriuatum ab aueo.

Locuples est qui pleraque tenet loca id est multas possessiones.

Lex est generale iussum populi aut plebis rogante magistratu.

Populus est omnis pars omnisque ordo ciuitatis.

Plebs uero dicitur: in qua gentes patriciorum non insunt.

Mulsum uinum melle decoctum. plautus in asinaria et cantaro mulsum date.

Peribolus templi est ipsius circumposita munitionum constructio.

Coloquintis agrestis cucurbita et uehementer amara quae more cucurbitae per terram flagella diffundit. foliorum uero et fructus uasualis instar cucumeris rotunditas coloquintis nomen dedit.

Classica sunt cornua quae conuocandi causa facta erant: et a calando id est uocando dicta. Virg. Classica iamque sonant.

Sinaxis concilium uel auditorium uel hora conueniendi dici potest.

Anaglifa relatura.

Musach sababi arca. ubi reges templum ingressuri elimosinam imponebant.

Carpasinus color est aureus sicut et cetrinus.

Luria siue cancellus est murus cenaculorum seu quorumlibet aedificiorum oram ambiens ab iniuria lapsus mihi incedentes defendens.

Reuma est eruptio uel fluor.

Scutra sunt uasa aenea aequalis in fundo et ore latitudinis ad calefaciendum uinum.

Annile uero ad offerendum uinum uasa aenea esse dicuntur.

Cathalogus ordinarius sermo.

Auarus quasi auidus eris et est littera iniunctura detracta: uel forsan simplex deriuatum ab aueo.

Locuples est qui pleraque tenet loca id est multas possessiones.

Legem generale iussum populi aut plebis rogante magistratu.

Populus est omnis pars omnisque ordo ciuitatis.

plebs uero ea dicitur in qua gentes patriciorum non insunt.

Plebiscitum est lex illa; quam plebs non populus sciuit.

Priua dixerunt antiqui: quod singula dicimus: unde priuilegia: quod non ab uniuersis ciuibus: sed a singulis conceptum uisumque est fieri: Inde etiam translatiue singulares specialesque cuiusque dignitatis eius priuilegia appellamus. hec omnia generali nomine rogationes appellantur: et confuse per se inuicem hec ponuntur.

Italia dicta est: quod in ea magna boum copia fuerit: qui greca ueteri lingua itale uocitati sunt.

Elegantia apud ueteres non de amoeniore ingenio sed nitidiore cultu ac uictu diceba-tur: nec in laude nec in uitio ponebatur. unde M. Cato in libro qui inscribitur Carmen de moribus. Sumptuosus cupidus elegans ititiosus irritusque habebatur. Unde apparet elegantem dictum antiquitus non ab ingenii elegantia; sed qui nimis lecto amoenoque cultu uictuque esset. postea elegans uituperii desiit esse: sed nulla laude dignabatur: nisi cuius elegantia erat moderatissima.

Qui mendacium dicit: fallitur. Qui mentitur: ipse non fallitur: alium fallere conatur.

Lictorem dicit Valerius a ligando appellatum esse: eoque qum magistratus populi romani uirgis quempiam uerberare iussisset: crura eius ac manibus ligari a uiatore solite sunt. Is qui ex collegio uiatorum officium ligandi habebat: lictor est appellatus. Tyro uero lictorem a lino uel a licio: quod idem est dici scripsit. Litio enim transuerso qui ministrabant inquit magistratibus cincti erant.

Intra Kalendas dicitur fieri: quod non

Plebiscitum est lex illa quam plebs non populus sciuit.

Priua dixerunt antiqui quod nos singula dicimus. Unde Priuilegium quod non ab uniuersis ciuibus sed a singulis conceptum uisumque est fieri. Inde etiam translatiue singulares specialesque cuiusque dignitatis eius priuilegia appellamus. Haec omnia generali nomine rogatio appellantur: et confuse per sunt inuicem haec pronuntiantur.

Italia dicta est quod in ea magna boum copia fuerit: quod uetere graeca lingua italos uocati sunt.

Elegantia apud ueteres non de ameniore ingenio: sed nitidiore cultu ac uictu dicebatur: nec in laude nec in uitio ponebatur. Unde M. Cato in libro quod inscribitur carmen de moribus: sumptuosus: cupidus: elegans: uitiosus: irritusque: habeatur. Unde apparet elegantem dictum antiquitus non ab ingenii elegantia: sed qui nimis lecto amenoque cultu uictuque esset. Postea elegans uituperii desiit esse. Sed nulla laude dignabatur nisi cuius elegantia erat modestissima.

Qui mendacium dicit fallitur. Sed quod mentitur ipse non fallitur. alterum fallere conatur.

Lictorem dicit ualerius a ligando appellatum esse. Eo quod cum magistratus populi romani uirgis quemquam uerberari iussissent crura eius ac manus ligari a uiatore solitae sunt. is qui ex collegio uiatorum officium ligandi habebat lictor est appellatus. Tiro uero lictorem a linio uel licio quod idem est dici scripsit licio enim transuerso quod ministrabant inquit magistratibus cincti erant.

Intra calendas dicimus fieri quod non

ante Kalendas: sed in Kalendis est: id est eo ipso die: quo Kalende sunt.

Pomerium est locus intra agrum effatum populi romani totius urbis circuitum pones muros regionibus certis determinatum: qui facit finem urbani auspicii.

Humanitas proprie est eruditio institutionum: que in bonas artes dicimus: quas sinceriter capiunt: appetuntque hi qui sunt maxime humanissimi. Huius enim scientie cura et disciplina ex uniuersis animantibus uni homini data est: idemque humanitas est appellata.

Manubias quidam predam que manibus capta est appellari existimant. Sed omnino aliud est preda: aliud manubie. Nam preda dicuntur corpora: que capta sunt: Manubie uero appellata est pecunia a questore ex uenditione prede redacta.

Faciem hominis quidam putant esse os tantum et oculum et genam: qum facies sit modus et factura quedam totius corporis a faciendo dicta: ut a specto species: et a fingendo figura. Unde pacuuius faciem hominis dixit pro statura. etate inquit integra feroci ingenio facie procera uirum. Nec solum hominum sed etiam rerum cuiuscunque modi aliarum facies dicitur: Nam et montis et maris et celi facies dicitur.

Profligare est deperdere et destruere.

Vestibulum a ue particula que tum intensionem tum minutionem significat et a stando componi uidetur. Qui enim amplas domos antiquitus faciebant: locum ante ianuam uacuum relinquebant: qui intra fores domus et uias medius esset. In eo loco qui dominum eius domus salutatum ueniebant: priusquam admitterentur consistebant: sed neque in uia neque intra

ante calendas sed in calendis est. in eo ipso die quo calendae sunt.

Pomerium est locus intra agrum et satum populi romani totius urbis circuitum pone muros regionibus certis determinatis quod facit finem urbani auspicii.

Humanitas proprie est eruditio institutioque in bonas artes; quas qui sinceriter capiunt appetuntque ii sunt maxime humanissimi. huius enim scientiae cura et disciplina ex uniuersis animantibus uni homini data est. Ideoque humanitas appellata est.

Manubias quidam praedam quae manibus capta sit appellari existimant. Sed omnino aliud est praeda: aliud manubiae. Nam praeda dicitur corpora quae capta sunt. Manubiae uero appellata est pecunia a quaestore ex uenditione praedae redacta.

Faciem hominis quidam putant esse os tantum et oculos et genas cum facies sit modus et factura quaedam totius corporis a faciendo dicta: ut a specto species et a fingendo figura. Unde pacuuius dixit faciem hominis pro statura. Aetate inquit integra feroci ingenio: facie procera uirum. Nec solum hominum sed etiam rerum cuiuscunque modi aliarum facies dicitur. Nam et montis et maris et coeli facies dicitur.

Profligare est deperdere et destruere.

Vestibulum a ue particula quae cum intentionem tum minutionem significat a stando componi uidetur. Q ri n. amplas domos antiquitus faciebant locum ante ianuam uacuum relinquebant. qui intra fores domus et uiam medius esset in eo loco qui dominum eius domus salutatum ueniebant priusquam admitterentur consistebant: et neque in uia stabant neque in

edes erant. Id illa ergo grandi constatione quasi quadam constabulatione supra dicta spacia sunt appellata.

Vescum quoque ex ue particula et esca compositum: et diminutionis uim capit. Aliter enim Lucretius uescum salem dicit ex edendi intentione. Aliter Lucilius appellat cum edendi fastidio.

Foenerator a foenore: Foenus a foetu dictum aiunt et quasi a quadam foetura pecunie parientis atque crescentis.

Assiduus ex ad et sedeo: uel asse et dando. et ita frequentem uel locupletem significat.

Quin coniunctio aliter dici putatur: qum quasi increpantes uel orantes dicimus: ut quin uenis: quin legis. Aliter qum dicimus: non dubium est: quin M. Tullius sit eloquentissimus. Aliter qum sic componimus: quasi priori uidetur contrarium. Non idcirco causam hanc non defendit Socrates: quin utile et honestum existimarit.

Soror dicitur quasi seorsum in hereditate non mansura.

Frater quasi fere alter.

Humilitas est modestia mentis: que non effertur supra se in elatione.

Mansuetudo est manuum assuetudo: ut puta qum que natura fera sunt manu tractari possunt.

Deuotio est post desecatam uitiorum rubiginem purum boni desiderium.

Misericordia est affectus subueniendi ex compassione proximi consurgens munditia cordis nec presentium delectatur: nec preteritorum recordatione.

aedes erant. Sed illa ergo grandis loci cum astatione quasi quadam cum constabulatione supradicta spatia uestibula sunt appellata.

Vescum quoque ex ue particula et esca compositum et diminutionis uim capit. Aliter n. Lucretius uescum salem dixit ex edendi intensione. Aliter lucilius uescum appellat cum edendi fastidio.

Foenerator a foenere: foenus a fetu dictum aiunt, et quasi a quadam foetura pecuniae crescentis ac parientis.

Assiduus ex ad et sedeo: uel asse dando exita frequentem et locupletem significat.

Quin conuinctio aliter dici putatur cum quasi increpantes uel exhortantes dicimus quin uenis quin vadis. Aliter cum dicimus. Non dubium est quin M. Tullius sit eloquentissimus. Aliter cum sic componimus: quod quasi priori uidetur contrarium. Non iccirco causam hanc non desendit socrates quin utile et honestum existimauerit.

Soror dicitur quasi seorsim in hereditate non mansura.

Frater quasi fere alter.

Humilitas sm quosdam est modestia mentis quae non effertur supra se in elationem. Sm uero consuetudinem latinorum est popularis quaedam ignobilitas seu deterrimum quod graeci dicunt.

Mansuetudo est manum assuetudo ut puta cum quae natura fera sunt manu tractari possunt.

Deuotio est post defecatam uitiorum rubiginem purum boni desiderium.

Misericordia est affectus subueniendi ex compassione proximi consurgens munditia cordis nec praesentium delectatione nec praeteritorum recordatione.

Pax diuersam habet significationem: aliter enim qum significat requiem animi: aliter qum propitiationem.	Pax diuersam habet significantiam: Aliter enim cum significat requietem animi. Aliter cum propitrationem.
	Pax est requies animae interiorum bonorum consideratione.
	Luctus uel dolor est uiuificatio mentis ex primo sensu boni uel mali consurgens.
Dipsas genus aspidis est grece: que latine dicitur Situla. Quencunque hec momorderit: siti perit: que adeo est parua: ut qum calcatur: non uideatur: cuius uenenum extinguit: quam sentiatur: nec tristitiam sentiat moriturus.	Dupas genus aspidis est graecae: quo latine dicitur stula. Quemcunque haec momorderit siti perit; quae adeo. est parua ut cum calcatur non uideatur. Cuius uenenum ante extinguit quam sentiatur. ne tristitiam sentiat moriturus.
Adeo particula que aliquando non aduerbii loco ponitur: ut Virgilius. Non adeo obtusi gestamus pectora poni. Rursum pro etiam ponitur: ut Senatus et adeo populus. ponitur etiam pro coniunctione completiua.	Adeo particula aliquando aduerbii loco ponitur: ut non adeo obtusa gestamus pectora teneri. Rursum pro etiam ponitur, ut senatus et adeo populus. Ponitur etiam coniunctione completiua.
Iobel grece id est dimittere: unde Iobileus id est remissus.	Iobel graece id est remittere. Unde Iubilens id est remissus.
Peta impetus gladiorum.	Peta impetus gladiorum. Unde cicero
Crusta est glacies.	crusta est glacies.
Hilarum letum, iocundum, ridens, plaudens, gaudens, gestiens.	FINIS.

Notes to Petronius Arbiter De Antiquis Dictionibus.

1. *Nitrum.* The description of the manufacture of natron, agreeing to some extent with that given by Pliny, Nat. Hist. 31, 10, 46, 109,* seems to indicate that the author speaks of the Egyptian article. This opinion is corroborated by the name *nitra provincia* (perhaps *nitrosa* or *nitraria provincia*), meaning the district of Naucratis and Memphis where natron was produced. Cf. Plin. Nat. Hist. 31, 10, 46, 111.† The name

* "In Aegypto autem multo abundantius sed deterius; nam fuscum lapidosumque est. Fit paene eodem modo quo sal, nisi quod salinis mare infundunt, Nilum autem nitrariis; haec cedente Nilo madent suco nitri XL diebus continuis, non ut in Macedonia statis. Si et imbres adfuerunt, minus e flumine addunt statimque ut densari coeptum est rapitur, ne resolvatur in nitrariis."

† "Nitrariae Aegypti circa Naucratim et Memphim tantum solebant esse, circa Memphim deteriores."

nitra provincia may possibly be an attempt to render in Latin what Strabo, 17, 803, 23, calls νομὸς νιτριώτης or νιτριῶτις.

2. *Kyrogrillus* or *Cyrogrillus* is undoubtedly a corruption of χοιρόγρυλλος. It is the porcupine, *hystrix*, which resembles the hedgehog, *ericius*. If we except the expression "simile muri vel (et) urso," the description, though brief, is correct. Cf. Plin. Nat. Hist. 8, 35, 53, 125: "Hystrices generat India et Africa spina contectas ac erinaceorum genere, sed hystrici longiores aculei et cum intendit cutem missilibus ora urguentium figit canum et paulo longius iaculatur; hibernis autem se mensibus condit, quae natura multis et ante omnia ursis." This last clause of Pliny furnishes, perhaps, an explanation of the expression "simile muri vel urso." If we take *simile* in the sense of similarity of habit, as well as similarity of form, the expression may be considered the substance of the definition, which, in the author from whom Petronius copied, was probably more full.

3. *Caparis.* The passage of Plautus occurs in Curculio, 1. 1, 90: "Voltisne olivas aut pulmentum aut capparim." The second quotation from Martial occurs in 3, 77, 5: "Capparin et putri cepas halece natantes." The expression "quae salitur" is explained by Dioscorides, 2, 204: ταριχεύεται δὲ ὁ καυλὸς αὐτῆς καὶ ὁ καρπὸς εἰς βρῶσιν.

4. *Hepicima* or *Epirima.* The writing of the Cod. Ricc. contains the elements of the true reading, viz. Epirima, which is to be corrected into Epinicia, ἐπινίκια, the letters *rim* containing as many strokes as *nici*. The word is used in the sense ascribed to it here, in Soph. Elect. 692: τούτων ἐνεγκὼν πάντα τἀπινίκια.

5. *Exedræ.* I follow the reading of the Cod. Vat. It is easy to understand how the copyist of the Cod. Ricc. should change *de oratore* into *et actoris*, but not how the words *nomen acceperunt* crept in. If the words *de oratore* be correct, the following *in eadem exedra* should be changed into *in eam exedram.* See De Orat. 3, 5, 17: "in eam exedram venisse."

6. *Scalptura.* There is evidently in both manuscripts a mixing up of two articles, the one on *sculptura*, the other on *histrio*, the second being incomplete. The form *histriaca*, which both manuscripts have, for *histrica*, does not occur anywhere else.

7. *Mulsum.* The quotation from Asin. of Plautus is 5, 2, 56: "Pueri plaudite et mi ob iactum cantharo mulsum date."

8. *Peribolus.* I have not found any passage in which the word, precisely in the meaning given, occurs. Suidas gives the definition ὁ τῆς νηός. Strange to say, Vitruvius does not use the term.

9. *Coloquintis.* The reading *dedit*, of the Cod. Ricc., in the last sentence, seems to be the true one. *Coloquintis* is undoubtedly the Latinized form of the Greek κολόκυνθα

or *κολοκύνθη* or *κολοκύντη*, from *κόλος*, *rounded off*, *truncated*, the reverse of *oblong.* The etymological remark, "rotunditas coloquintis nomen dedit," indicates some knowledge of Greek on the part of the author, or of the source from which he drew. Cf. Suidas: *κολοκύντη· μαρίκη. Καὶ παροιμία· κολοκύντης ὑγιέστερος.*—The reading *usualis* seems to be the true one, in the sense of *common*, *ordinary.* I should prefer the *vasualis* of the Cod. Ricc. if there were any other authority for the word.

10. *Classica.* The quotation from Virgil is in Aen. 7, 637: "Classica iamque sonant; it bello tessera signum." Besides this, and a few other poetic passages, there is no instance of *classicum* meaning the instrument, with the exception of Pseudo-Asconius to Divin. Verr. 17: "Sed quia hic *in classe* dixit, possumus intelligere ad hoc symphoniacos capi solere, ut in classe pugnantibus classicum canant: unde ipsi tibiae classis nomen est positum classicum."

11. *Sinaxis.* This is, of course, the Greek *σύναξις*, and should therefore be written *synaxis.* I know of no instance of the word being used in the sense of *hora conveniendi.*

12. *Anagliffi* or *anaglifa.* While the Cod. Vat. gives the correct definition, the Cod. Ricc. approaches nearer to the correct form of the word. The word is from the Greek *ἀναγλυφή*, *embossed work*, and *ἀνάγλυφος*, *embossed.* The adjective *ἀνάγλυφα* being sometimes used substantively * for *ἀναγλυφή*, I infer from the definition *celaturae* (plural), that the genuine text is *anaglypha.* In the later Latinity, the substantive *anaglypha* (*ἀναγλυφή*) occurs, as well as the adjective *anaglyphus.*

13. *Musach.* This is undoubtedly the Hebrew word מוּסָךְ. Both manuscripts are evidently wrong in the word *sababi;* it should be *sabati*, מוּסַךְ הַשַּׁבָּת, *the porch of the sabbath;* or, as the English version has it, "the covert for the sabbath." Cf. 2 Kings xvi. 18. I know of no other passage in which the custom of the kings of Israel depositing alms in this porch when entering the temple is mentioned. The article is therefore of interest to Jewish antiquarians.

14. *Carpasinus.* The word is probably identical with the Greek *καρπάσινος*, *made of fine Spanish flax* (cf. Strab. 7, 294: *καρπασίνας ἐφαπτίδας ἐπιπεπορπημέναι*), and signifies here the color of this flax.

15. *Lurica* or *luria.* The text, in both manuscripts, is undoubtedly corrupt. I entertain no doubt that the correct reading is *lorica.* In the last clause, the Cod. Ricc. seems to have in part the better reading; *incedentes*, if not indispensable, rendering

* Cf. Isid. 19, 14: "*Anaglyfa*, quod superius sint sculpta. Graeci enim *ἄνω* sursum, *γλυφήν* sculpturam dicunt, id est sursum sculpta."

the sense clearer. The change of *inibi* into *mihi* is easily explained. — *Lorica* is not infrequently used in the sense of enclosure for protection. Cf. Ammian. 24, 5, 18: "Erat etiam in hac eadem regione extentum spatium et rotundum loricae ambitu circumclausum destinatas regiis voluptatibus continens feras." Apul. Met. 6, 30, 443: "Iam domus eorum extremam loricam perveneramus;" Hildebrand explaining the word by *ambitio* or *περίβολος*. Vitr. 2, 8, 18: "Cum enim in tecto tegulae fuerint fractae aut a ventis deiectae, qua possit ex imbribus aqua perpluere, non patietur lorica testacea laedi laterem sed proiectura coronarum reiiciet extra perpendiculum stillas, et ea ratione servabit integras lateritiorum parietum structuras." The definition of Petronius has perhaps special reference to the application of *lorica* or *loricula* in translating the Hebrew term מַעֲקֶה לְגַגֶּךָ, or the *στεφάνη* of the LXX., in Deut. xxii. 8. Cf. J. Lipsius, Poliorc. 2, 2.*

16. *Reuma.* The word should of course be written *rheuma*, being the Greek *ῥεῦμα* in its medical signification.

17. *Scutra.* The Cod. Ricc. has undoubtedly the correct reading. The word occurs in Cato de R. R. 157, 11: "ubi in scutra (al. scutea, scrutha, schutra, chutra) fervefeceris, foetae sub sellam supponito pertusam;" and Plaut. Pers. 1, 3, 8: "Bene ut in scutris (stutris, strutris, strutheis) concaleant." There being in both passages a variety of readings, this article tends to confirm the reading *scutra.*

18. *Amulae* or *Annile.* The Cod. Vat. gives the better reading; the change in the Cod. Ricc. of *amulae* into *annile* is easily explained. The word should, however, be written *amullae*, being the Latinized form of the modern Greek *ἄμουλλα*, *bottle*, *vial*, which is unquestionably derived from *ampulla*, or the vulgar form *amula* † or *amulla*, a corruption of *ampulla.* It appears probable in general, as indicated in this instance, that many words of the modern Greek were derived from the *lingua rustica.* That the term *amullae* is, in meaning, closely connected with *scutra*, is apparent from the connecting particle *vero.*

* Most Latin translations of the Old Testament render the Hebrew term by *murus* or *septum.* Hieronymus translates, "facies murum tecti per circuitum;" Osiander, "facies murum, peribolum, tecti per circuitum." The translation of Imman. Tremellius and Franc. Junius has "facies loricam ad tectum tuum," and adds in a note, "vel loricationem, i. *θρίγκωμα* sive *περίβολον*, ut Graecis appellatur, in solariis et planis aedificiorum tectis, ut tecta Palaestinae sunt, necessarium." The LXX. translates: *καὶ ποιήσεις στεφάνην τῷ δώματι.* Rosenmüller, in his Scholia, explains the word מַעֲקֶה: "ambitus, lorica, septum peribolum circumcirca, a radice עָקָה, detinuit, retinuit;" Gesenius, in his Thesaurus, "lorica, qua tectum cingitur, nequis delabatur."

† Cf. Du Cange's Glossarium, s. v. *ama* and *amula.*

19. *Catalogus* or *cathalogus*. Slight difference between the two manuscripts in the spelling of the word; none in the definition. What is *ordinarius sermo?* Does it signify "regular customary language," a meaning which does not belong to *catalogus*, or does it mean "a treatise or book in which a certain order is observed, a list"? I am in favor of the latter interpretation, although I cannot support it by any other authority.

20. *Avarus*. Slight difference, in the text, between the two manuscripts. This word, as well as several others, may furnish some clew to the source of the material of this fragment, if not to the author. Cf. Aul. Gell. N. A.* 10, 5: "*Avarus* non simplex vocabulum sed iunctum copulatumque esse P. Nigidius dicit in commentariorum undetricesimo: 'Avarus enim, inquit, appellatur qui avidus aeris est. Sed in ea copula e litera, inquit, detrita est. Item *locupletem* dictum ait ex compositis vocibus, qui pleraque loca, hoc est, qui multas possessiones teneret.' Sed probabilius id firmiusque est, quod de *locuplete* dixit; nam de *avaro* ambigitur; cur enim non videri possit ab uno solum verbo inclinatum, quod est *avet?*" There is great similarity, in the substance of the information, between Petronius and Gellius, although the former expresses himself more concisely. What does this similarity indicate? that Petronius borrowed from Gellius, or that both drew from a common source? The work of P. Nigidius Figulus (a contemporary of Cicero, and distinguished as a mathematician and astronomer, as well as grammarian), which had the title *Commentarii Grammatici*, was probably a collection of lexicographical, grammatical, and etymological observations, gathered without any attempt at a systematical arrangement, from which our fragment may in part have been taken. Compare the ridiculous etymology of *avidus* in Festus.

21. *Locuples*. The two manuscripts agree. It is apparent that this article is derived from the same source as the preceding.

22. *Lex* or *legem*. With the exception of the form of the word itself, there is no difference between the two manuscripts. Genuine Roman definition of the word, such as might be given by Nigidius or any other well-informed man, who knew from experience the institutions of the republic. Cf. A. Gell. N. A., 10, 20: "Ateius Capito publici privatique iuris peritissimus, quid lex esset, hisce verbis definivit. 'Lex, inquit, est generale iussum populi aut plebis rogante magistratu.'" It is apparent that the definition of Petronius is copied verbatim from that of Capito.†

* I quote, in this and all other citations from A. Gellius, from the edition of M. Hertz, 1853.

† C. Ateius Capito, a distinguished lawyer and rival in the science of the law of Q. Antistius Labeo; Consul Suffectus 6 p. C., 759 U. C.; he died 22 p. C., 775 U. C.

23. *Populus.* The two manuscripts agree. The definition of the word, as of the preceding, is genuine Roman. See the following note.

24. *Plebs.* There is a trifling difference only between the two manuscripts. As to the definition, cf. A. Gell. N. A. 10, 20: "*Plebem* autem Capito in eadem definitione seorsum a populo divisit, quoniam in populo omnis pars civitatis omnesque eius ordines contineantur; plebes vero ea dicatur, in qua gentes civium patriciae non insunt. Plebisscitum igitur est, secundum eum Capitonem, lex, quam plebes non populus accipit."

25. *Plebiscitum.* Agreement of the two manuscripts. Capito, according to Gellius, has *accipit* for *scivit.* What may be inferred from this difference, the definition being essentially that of Capito? The difference may be owing to the circumstance that Gellius, in copying Capito, substituted *accipit* for *scivit.* If the change was made by Petronius, it would prove his accurate knowledge of the language, since *scivit* is quite as good as *accipit.*

26. *Priva.* There are several, although not very important, differences between the two manuscripts. In connection with "singulares specialesque cuiusque dignitatis," a substansive, perhaps *leges*, is to be supplied. Cf. A. Gell. (who draws from Capito), N. A. 10, 20: "quocirca privilegia potius vocari debent, quia veteres priva dixerunt, quae nos singula dicimus. . . . Nam et plebisscita et privilegia translaticio nomine legis appellaverunt, eademque omnia confuso et indistincto vocabulo rogationes dixerunt." The clause, "Inde etiam translative singulares specialesque cuiusque dignitatis eius privilegia appellamus," is not comprehended among the various explanations of Capito, as given by Gellius, and may have been taken directly from Capito. This circumstance goes far to prove that, although Petronius has in several instances definitions which are also given by Gellius, he drew directly from the sources which were also used by Gellius.

27. *Italia.* Some slight differences between the two manuscripts. Festus gives the general substance of this definition, but adds also another: "Italia dicta, quod magnos italos, hoc est boves, habeat. Vituli etenim ab Italis itali sunt dicti. Italia ab Italo rege."

28. *Elegantia.* With the exception of *habebatur* (Cod. Ricc. *habeatur*) and *moderatissima* (Cod. Ricc. *modestissima*) the two manuscripts agree. I am inclined to think that the clause, "nec in laude nec in vitio ponebatur," is not in its proper place, the *unde* evidently referring to the *nitidiore cultu ac victu*, and not to the clause *nec in laude*, &c. This clause may be placed after *moderatissima*, repeating in other words the same idea. As to the definition, it is interesting to compare A. Gell. N. A. 11, 2: "Elegans homo non dicebatur cum laude, sed id fere verbum ad aetatem M. Catonis vitii non laudis fuit.

Est namque hoc animadvertere cum in quibusdam aliis tum in libro Catonis, qui inscribtus est Carmen de moribus. Ex quo libro verba haec sunt. 'Avaritiam omnia vitia habere putabant; sumptuosus, cupidus, elegans, vitiosus, inritus qui habebatur, is laudabatur;' ex quibus verbis apparet elegantem dictum antiquitus non ab ingenii elegantia, sed qui nimis lecto amoenoque cultu victuque esset. Postea elegans reprehendi quidem desiit, sed laude nulla dignabatur, nisi cuius elegantia erat moderatissima."

29. *Mendacium.* Slight differences between the two manuscripts. The reading of the Cod. Ricc., *alterum* for *alium*, is better. As we learn from A. Gell. N. A. 11, 11, our author gives in a very concise and pithy manner the substance of a definition of Nigidius: "Verba sunt ipsa haec P. Nigidii, hominis in studiis bonarum artium praecellentis, quem M. Cicero * ingenii doctrinarumque nomine summe reveritus est. 'Inter mendacium dicere et mentiri distat; qui mentitur, ipse non fallitur, alterum fallere conatur: qui mendacium dicit, ipse fallitur.' Item hoc addidit: 'Qui mentitur, inquit, fallit, quantum in se est: at qui mendacium dicit, ipse non fallit, quantum in se est.' Item hoc quoque super eadem re dicit: 'Vir bonus, inquit, praestare debet, ne mentiatur: prudens ne mendacium dicat: alterum incidit in hominem, alterum non."

30. *Lictorem.* Some trifling differences between the two manuscripts. The matter is derived from the work of Valgius Rufus, whom our manuscripts erroneously call Valerius, and Tiro. Cf. A. Gell. N. A. 12, 3: "Valgius Rufus in secundo librorum, quos inscripsit de rebus per epistulam quaesitis, lictorem dicit a ligando appellatum esse, quod cum magistratus populi Romani virgis quempiam verberari iussissent, crura eius et manus ligari vincirique a viatore solita sint, is, qui ex conlegio viatorum officium ligandi haberet, lictor sit appellatus; utiturque ad eam rem testimonio M. Tullii verbaque eius refert ex oratione, quae dicta est pro C. Rabirio: 'Lictor, inquit, conliga manus.' Haec ita Valgius. Et nos cum illo sentimus, sed Tiro Tullius, M. Ciceronis libertus, 'lictorem vel a limo vel a licio dictum scribsit; licio enim transverso, quod limum appellatur, qui magistratibus, inquit, praeministrabant, cincti erant.'" This article, unless it be copied from some other unknown compiler, — not Gellius, — would seem to be the work of Petronius, who collected his materials from various sources, in this instance from Valgius Rufus and Tiro, and not necessarily borrowed from Gellius. As to Valgius Rufus, it is probable that he is the same person with C. Valgius Rufus who was Consul Suffectus in 742 U. C., 12 a. C., and known as a poet.

* Cicero several times mentions P. Nigidius as his friend and stanch political supporter; of his learning he speaks, Fam. 4, 13, 3: "Nunc P. Nigidio, uni omnium doctissimo . . . . ne benigne quidem polliceri possum."

31. *Intra Kalendas.* The explanation seems to be taken verbatim from Apollinaris Sulpicius,* according to A. Gell. N. A. 12, 13: "intra Kalendas igitur non ante Kalendas est sed in Kalendis, id est, eo ipso die quo Kalendae sunt." There is a trifling difference in the text of the two manuscripts, which is easily explained, the copyist of the Cod. Ricc. misapprehending the abbreviation .i. of his original (which is in the Cod. Vat.), and changing it into *in.*

32. *Pomoerium.* There is some slight difference in the text of the two manuscripts. Cf. A. Gell. N. A. 13, 14: "Pomerium quid esset, augures populi Romani, qui libros de auspiciis scribserunt, istiusmodi sententia definierunt; 'Pomerium est locus intra agrum effatum per totius urbis circuitum pone muros regionibus certeis determinatus, qui facit finem urbani auspicii.'" The definition of Petronius may have been taken from the same source, viz. the *Libri de Auspiciis.* However this may be, the passage quoted by Gellius enables us to correct the errors of both manuscripts.

33. *Humanitas.* The text of both manuscripts is very imperfect. The passage in A. Gell. N. A. 13, 16 enables us to some extent to reconstruct it: "humanitatem appellaverunt id propemodum, quod Graeci παιδείαν vocant, nos eruditionem institutionemque in bonas artis dicimus. Quas qui sinceriter percupiunt adpetuntque, hi sunt vel maxime humanissimi. Huius enim scientiae cura et disciplina ex universis animantibus uni homini datast, idcircoque humanitas appellata est." This is an important instance to show that Petronius, in part at least, borrowed from Gellius; for the above definition, evidently identical with that of Petronius, seems to be original with Gellius, in expression at least, if not in substance. For this reason, I have not only in those passages in which the two manuscripts differ followed that which agrees with Gellius, but I should not be disinclined to adopt the reading of Gellius *percupiunt,* although both manuscripts have *capiunt.* The double superlative "maxime humanissimi" is to be noticed.

34. *Manubias.* Almost perfect agreement of the two manuscripts. Cf. A. Gell. N. A. 13, 24: "Quid igitur? Simile est, inquit, apud eundem (Ciceronem) in *praeda* et *manubiis?* Nihil, nihil profecto istiusmodi est. Nam neque ornatius fit additis manubiis neque exaggeratius modulatiusve; sed aliud omnino praeda est, ut in libris rerum verborumque veterum scribtum est, aliud manubiae. Nam praeda dicitur corpora ipsa rerum, quae capta sunt; manubiae vero appellatae sunt pecunia a quaestore ex venditione praedae redacta." It is evident that the definition, quoted here by Favorinus,†

* C. Sulpicius Apollinaris, a poet and grammarian, lived in the middle of the second century of our era, during the reign of the Antonines.

† Favorinus was a contemporary of the Emperor Hadrian.

as taken from the "libri rerum verborumque veterum," is the same as that of Petronius. It is possible that in other instances also, in which Gellius or his interlocutors do not mention, or even allude, to their sources, the definitions are not their own, but derived from earlier sources ("libri rerum verborumque veterum"). Nay, I am inclined to go a step further, and suppose that, in many instances in which Gellius communicates certain information, or puts it in the mouths of other persons, contemporaries and friends of his, the information belonged neither to these interlocutors nor to Gellius, but was derived from earlier works. In case Petronius's independence of Gellius can be at all maintained, this hypothesis may meet the difficulty presented by passages such as the preceding on *humanitas*, in which the information given appears to proceed from Gellius. This kind of integrity of acknowledging the sources of information, was not so clearly understood among the ancients as it is now. Pliny the elder furnishes a striking illustration. Although he took the material of many articles from the work of Dioscorides of Anazarbus, and sometimes copied him verbatim, yet in one instance only is he supposed to refer to him, 36, 20, 37, 144: "Schistos et haematites cognationem habent. Haematites invenitur in metallis, ustus mini colorem imitatur; uritur ut Phrygius, sed non restinguitur vino; adulteratum haematiten discernunt venae rubentes et friabilis natura. Oculis cruore suffusis mire convenit; sistit profluvia mulierum potus; bibunt et qui sanguinem reiecerunt cum suco Punici mali; et in vesicae vitiis efficax; bibitur et in vino contra serpentium ictus. Infirmiora omnia eadem in eo quem schiston appellant; in iis commodior croco similis, peculiaris explendis oculorum lacunis in lacte muliebri, procidentisque oculos praeclare cohibet. Haec est sententia eorum qui nuperrime scripsere." Comparing the two sections of Diosc. 5, 144 and 145, *περὶ αἱματίτου* and *περὶ σχιστοῦ*, it will be found that the description of Dioscorides, besides being much fuller than that of Pliny, contains all the particulars mentioned by the latter: *τῷ κινναβάρει ἐοικυῖαν — καίεται δὲ ἐμφερῶς τῷ Φρυγίῳ λίθῳ τοῦ οἴνου περιῃρημένου — ἀπελέγχεται δὲ ὁ κεκακοτεχνημένος πρῶτον μὲν ταῖς διαφύσεσι — καὶ ὑφαίμοις ὀφθαλμοῖς — πίνεται δὲ σὺν οἴνῳ πρὸς δυσουρίαν καὶ ῥοϊκὰς καὶ πρὸς αἵματος πλύσεις σὺν χυλῷ ῥοιᾶς — δύναμιν δὲ τὴν αὐτὴν τῷ αἱματίτῃ εἰσφέρεται, τῇ εὐτονίᾳ μόνον λειπόμενος αὐτοῦ — ἄριστος δὲ εἶναι δοκεῖ ὁ παρακροκίζων τῇ χρόᾳ — πληροῖ δὲ καὶ κοιλώματα γυναικείῳ διεθεὶς γάλακτι καὶ πρὸς προπτώσεις.*

35. *Faciem.* The two manuscripts differ in a few unimportant forms only. As to the matter, cf. A. Gell. N. A. 13, 29: "Animadvertere est pleraque verborum Latinorum ex ea significatione, de qua nata sunt, decessisse vel in aliam longe vel in proximam, eamque decessionem factam esse consuetudine et inscitia temere dicentium, quae cuiusmodi sint, non didicerint. Sicuti quidam faciem esse hominis putant os tantum

et oculos et genas, quod Graeci πρόσωπον dicunt: quando facies sit forma omnis et modus et factura quaedam corporis totius a faciendo dicta, ut a (b a) spectu (Gronov. ab aspectu) species et a fingendo figura. Itaque Pacuvius in tragoedia, quae Niptra scribitur, faciem dixit hominis pro corporis longitudine: 'Aetate, inquit, integra, feroci ingenio, facie procera virum.' Non solum autem in hominum corporibus sed etiam in rerum cuiusquemodi aliarum facies dicitur. Nam montis et caeli et maris facies, si tempestive dicatur, probe dicitur." While the general agreement of Petronius and Gellius in this article is apparent, some striking differences in the language, as *specto* — *spectu*, *statura* — *corporis longitudine*, *cuiuscunque* — *cuiusquemodi*, are not to be overlooked.

36. *Profligare.* There is no difference between the two manuscripts. Cf. A. Gell. 15, 5: "Sicut alia verba pleraque ignoratione et inscitia improbe dicentium, quae non intellegant, deflexa ac depravata sunt a ratione recta et consuetudine, ita huius quoque verbi, quod est *profligo*, significatio versa et corrupta est. Nam cum ab adfligendo et ad perniciem interitumque deducendo inclinatum id tractumque sit, semperque eo verbo, qui diligenter locuti sunt, ita usi sint, ut *profligare* dicerent prodigere et deperdere, *profligatasque* res quasi proflictas et perditas appellarent: nunc audio aedificia et templa et alia fere multa, quae prope absoluta adfectaque sunt, in profligato esse dici, ipsaque esse iam profligata." There is similarity of sense, but great difference in the mode of description.

37. *Vestibulum.* Without taking into consideration some variations between the two manuscripts, this article belongs to the more imperfect as regards the text. Cf. A. Gell. N. A. 16, 5: "Quod Sulpicium autem Apollinarem memini dicere virum eleganti scientia ornatum, huiuscemodi est: *Ve* particula, sicuti quaedam alia, tum intentionem significat tum minutionem. Nam vetus et ve(he)mens, alterum ab aetatis magnitudine compositum elisumque est, alterum a mentis vi atque impetu dicitur. *Vescum* autem, quod ex *ve* particula et *esca* copulatum est, utriusque diversae significationis vim capit. Aliter enim Lucretius vescum salem dicit ex edendi intentione: aliter Lucilius vescum appellat cum edendi fastidio. Qui domos igitur amplas antiquitus faciebant, locum ante januam vacuum relinquebant, qui inter fores domus et viam medius esset. In eo loco qui dominum eius domus salutatum venerant, priusquam admitterentur, consistebant, et neque in via stabant, neque intra aedes erant. Ab illa ergo grandis loci consistione et quasi quadam stabulatione vestibula appellata sunt, spatia, sicuti diximus, grandia ante fores aedium relicta, in quibus starent, qui venissent, priusquam in domum intromitterentur." The substance of the definition, and, to some extent, even the language, are the same, the principal difference being in the order of the two articles *vestibulum* et *vescum*.

38. *Vescum.* The two manuscripts differ but slightly. As to the matter, compare the passage from Gellius in the preceding paragraph.

39. *Foenerator.* A slight difference only in the text of the two manuscripts. Cf. A. Gell. N. A. 16, 12: "Faenerator enim, sicuti M. Varro in libro tertio de sermone Latino scripsit, a faenore est nominatus; faenus autem dictum ait a fetu et quasi a fetura quadam pecuniae parientis atque increscentis." Whether the definition of Petronius is directly derived from Varro or from Gellius is a question difficult of settlement, as the third book of Varro de Lingua Latina is no longer extant.

40. *Assiduus.* A slight difference between the two manuscripts. As to the definition, cf. A. Gell. N. A. 16, 10: "Adsiduus in XII tabulis pro locuplete et facile facienti dictus aut ab (assiduis ab) aere dando, cum id tempora reipublicae postularent, aut a muneris pro familiari copia faciendi adsiduitate." Cf. Fest.: "Assiduus dicitur, qui in ea re, quam frequenter agit, quasi consedisse videatur. Alii assiduum locupletem, quasi multorum assium, dictum putarunt. Alii eum, qui sumptu proprio militabat, ab asse dando vocatum existimarunt." The similarity of these three definitions is not sufficiently great to prove the fact of one being borrowed from the other; it rather points to a common source. The difference between Petronius and Gellius is especially to be noticed, as having possibly some bearing on the general relation of the two. In this instance the resemblance between Petronius and Festus is greater than between Petronius and Gellius.*

41. *Quin.* The text of the two manuscripts differs in some particulars. As to the matter, cf. A. Gell. N. A. 17, 13: "*Quin* particula, quam grammatici coniunctionem appellant, variis modis sententiisque connectere orationem videtur. Aliter enim dici putatur, cum quasi increpantes vel interrogantes vel exhortantes dicimus: 'quin venis? quin legis? quin fugis?' aliter, cum ita confirmamus: 'non dubium est, quin M. Tullius omnium sit eloquentissimus,' aliter autem, cum sic componimus, quod

* It may be interesting to compare the other "loci classici" relating to this word. Cic. de Re Publ. 2, 22, 40: "In quo etiam verbis ac nominibus ipsis fuit diligens, qui, cum locupletes assiduos appellasset ab aere dando, eos, qui aut non plus mille quingentum aeris aut omnino nihil in suum censum praeter caput attulissent, proletarios nominavit," etc. Top. 2, 10: Cum lex assiduo vindicem assiduum esse iubeat, locupletem iubet locupleti: locuples enim est assiduus, ut ait Aelius, appellatus ab asse dando." M. Ter. Varro de L. L. 7, 99: "Apud eundem (Plautum, Cistell. 1, 1, 7) quod est: 'Mihi frequentem operam dedistis;' valet assiduam. Itaque qui adest, *assiduus*." M. Fab. Quint. Inst. Or. 5, 10, 55: "Praeterea finimus aut vi, sicut superiora, aut ἐτυμολογίᾳ, ut si *assiduum* ab aere dando, et *locupletem* a locorum, *pecuniosum* a pecorum copia." Charis. 1, 58: "Adsiduus quidam per d scribunt, quasi sit a sedendo figuratum, sed errant. Nam cum a Servio Tullio populus in quinque classes esset divisus, ut tributum, prout quisque possideret, inferret, ditiores, qui asses dabant, assidui dicti sunt. Et quoniam soli in negotiis publicis frequentes aderant, eos qui frequentes adsunt, assiduos ab assibus dixerunt." Caper de Verb. Dub.: "Assiduus, non asseduus, ab assidendo."

quasi priori videtur contrarium: 'non idcirco causas Isocrates non defendit, quin id utile esse et honestum existimarit.'" Gellius extends his article further; but both from the beginning, — "quam grammatici coniunctionem appellant," — and from the concluding clause, — "Quod quia longioris dissertationis est, poterit, cui otium est, repperire hoc in P. Nigidii commentariis, quos grammaticos inscripsit," — it is evident that the material of this article is not original with Gellius, but drawn from the work of Nigidius; and Petronius, having evidently a practical object in view and aiming at great conciseness, was satisfied with even a smaller portion of the definition of Nigidius, containing the three principal meanings and applications of *quin.* This article, again, is a strong reason for supposing that Petronius did not borrow from Gellius. The difference in the reading, Socrates and Isocrates, is to be noticed. Petronius appears to have the better reading, Nigidius undoubtedly referring to the reasons which influenced Socrates in not employing legal aid at his trial.*

42. *Soror.* There is no important difference between the two manuscripts. As to the matter, cf. A. Gell. N. A. 13, 10: "Praeterea in libris, quos ad praetoris edictum scribsit (Labeo Antistius), multa posuit partim lepide atque argute reperta. Sicuti hoc est, quod in quarto ad edictum libro scriptum legimus: 'Soror, inquit, appellata est, quod quasi seorsum nascitur separaturque ab ea domo, in qua nata est, et in aliam familiam transgreditur.' Fratris autem vocabulum P. Nigidius, homo inpense doctus, non minus arguto subtilique ἐτύμῳ interpretatur: 'Frater, inquit, est dictus quasi fere alter.'" The difference between the definition of *soror* of Labeo and Petronius is such that it is probable that Petronius borrowed from Nigidius rather than Labeo in the article *soror* as well as *frater.*

43. *Frater.* There is no difference between the two manuscripts. The circumstance that the article *frater* follows the article *soror* in Petronius, as in Gellius, might be viewed as a reason for supposing Petronius to be a borrower from Gellius; but the juxtaposition of these two words, on account of the intimate connection of meaning (bearing in mind, too, that even those writers, grammarians or lexicographers, who adopt, in general, an alphabetical arrangement, do not in every particular strictly adhere to it, e. g. Festus and Nonius), may have existed in the works of Labeo and Nigidius, from which Petronius and Gellius drew. Cf. Fest.: "*Frater* a Graeco

* The anecdote alluded to in this paragraph is, with some slight modification, related by Diogenes Laertius 2, 40: ὁ δ' αὖ φιλόσοφος Λυσίου γράψαντος ἀπολογίαν αὐτῷ διαγνοὺς ἔφη, Καλὸς μὲν ὁ λόγος, ὦ Λυσία, οὐ μὴν ἁρμόττων ἐμοί· δηλαδὴ γὰρ ἦν τὸ πλέον δικανικὸς ἢ ἐμφιλόσοφος· εἰπόντος δὲ τοῦ Λυσίου, Πῶς, εἰ καλός ἐστιν ὁ λόγος, οὐκ ἂν σοι ἁρμόττοι; ἔφη, Οὐ γὰρ καὶ ἱμάτια καλὰ καὶ ὑποδήματα εἴη ἂν ἐμοὶ ἀνάρμοστα; The change of Socrates into Isocrates by a careless copyist was an easy and natural one.

dictus est φρήτρη, vel quod sit fere alter." Cf. Non.: "*Fratrum* proprietatem Nigidius accuratissime dixit, 'frater est, inquit, dictus quasi fere alter.'"

44. *Humilitas.* There is a considerable difference between the two manuscripts, the Cod. Vat. giving one definition only, the moral, while the Cod. Ricc. contains a second, the political or social. It is remarkable that neither Festus, Nonius, nor Gellius mentions the word, although a good Latin word, and used by the best writers both in the moral and political sense. The fact that Gellius neither in the extant part of his work, nor, as far as we can judge, in the lost eighth book, mentions the word *humilitas*, settles the question that Petronius did not in this instance, and perhaps not in any other, borrow from Gellius.

45. *Mansuetudo.* There is no difference between the two manuscripts. Gellius does not speak of the word. Cf. Fest.: "Mansuetum ad manum venire suetum. Alii aiunt mansuetum dictum neque ex misericordia maestum neque ex crudelitate saevum sed modestia temperatum." Cf. Non. 59: "Mansuetum dictum est quasi manu adsuetum, quod omnia, quae sunt natura fera, manuum permultione mitescant." From the agreement of Petronius and Nonius it is to be inferred, either that they drew from a common source, or that one borrowed from the other. If Petronius be the borrower, it is not easy to determine from this circumstance alone the age of Petronius, as there is a great difference of opinion as to the age to which Nonius belongs, some placing him at the close of the second century, and others at the commencement of the fifth.

46. *Devotio.* There is a slight difference between the two manuscripts; the Cod. Ricc. undoubtedly gives the better text. The definition seems to indicate a Christian source. The word is certainly not used in this sense by any classical writer.

47. *Misericordia.* Slight difference between the two manuscripts; the Cod. Ricc. giving the better reading. These, too, appear to be definitions proceeding from a Christian source, especially the second.

48. *Pax.* Great difference between the manuscripts. The first definition appears to be of Christian origin: * perhaps also the second, if we supply *dei* instead of *deorum* after *propitiationem.* The third definition, contained in the Cod. Ricc. only, is of the same description.

49. *Luctus vel Dolor.* This term, with its definition, is contained in the Cod. Ricc. only. The definition is evidently of Christian origin, but too comprehensive, inasmuch

* Cf. Comment. Hieronymi Lib. III. in Epist. ad Ephes. c. vi.: "inter haec (dona) pax non minimum possidet locum, quae superat omnem sensum et custodit corda intellectusque sanctorum, serenitas quaedam atque tranquillitas animae quiescentis."

as it describes not merely *dolor* and *luctus*, but also their opposites. The language itself (*vivificatio* *) shows the late age of the definition.

50. *Dipsas.* There is some difference between the two manuscripts. The word is in the Cod. Ricc. incorrectly spelled. Cf. Solin. 27, 31: "Plures diversaeque aspidum species verum dispares effectus ad nocendum: dipsas siti interficit; hypnale, quod somno necat teste etiam Cleopatra, emitur ad mortem." It is apparent that Petronius has derived his description, which is more full than that of Solinus, from another source. Cf. Dioscorid. Ther. 13: Τοῖς δὲ δηχθεῖσιν ὑπὸ διψάδος ἄστεγνος ὄγκος ἔγκειται καὶ δίψος ἐπιτεταμένον ἰσχυρῶς, ὥστε ἀπλήρωτον καὶ ἀδιάλειπτον εἶναι.

51. *Adeo.* There is some difference between the two manuscripts. F estus gives simply the etymology of the word: "*Adeo* duas habet significationes. Nam cum prima acuta effertur, idem significat, quod accedo, ut cum dicimus *adeo praetorem.* Cum autem secunda, idem quod usque eo, non quidem secundum rationem, quia *ad* praepositio accusativis accommodata est, sed vetusta quadam loquendi consuetudine." Priscianus, L. 16 de coniunctione, speaks of a *coniunctio completiva.* † The passage of Virgil quoted by Petronius is Æn. 1, 567: "Non obtusa adeo gestamus pectora Poeni." Whence the material of the article is taken I am not able to say; perhaps from Nigidius.

52. *Iobel.* There is some difference between the two manuscripts. Petronius is of course mistaken in calling the word Greek; it is Hebrew, יוֹבֵל, *a shout*, from the verb יָבַל, *to shout.* The word has not etymologically the signification of *dismission* or *release*, but received it in consequence of one of the special Jewish customs connected with the year of jubilee (שְׁנַת הַיּוֹבֵל, so called because it was announced by the sound of trumpets), in which the hired servants were freed (Lev. xxv. 41). The Vulgata translates the term *annus jubileus ;* but whether the word *jubileus* is in any Christian writer used in the sense of *remissus*, released, I am not able to say. The signification which approaches nearest to that of Petronius occurs Isidor. 5, 37: "Jubileus interpretatur remissionis munus. Est enim Hebraicus et sermo et numerus, qui septenis annorum hebdomadibus, id est quadraginta novem annis, texitur, in quo clangebatur tubis, et ad omnes revertebatur antiqua possessio, debita absolvebantur, confirmabantur libertates."

53. *Peta.* There is no difference between the two manuscripts. Provided the

* Cf. Augustinus in Psalmum xl.: "Sed vivificationem nobis illam promittit, de qua dicit apostolus," etc.

† "Completivae sunt vero, autem, quidem, equidem, quoque, enim, nam, namque et fere quaecunque coniunctiones ornatus causa vel metri nulla significationis necessitate ponuntur, hoc nomine nuncupantur." This, of course, is not the place to speak of the inadequacy of Priscian's definition.

spelling of the word be correct, it may be a popular or military slang-word, derived from *petere.*

54. *Crusta.* Both manuscripts agree as to the word and its definition; but the Cod. Ricc. has between *gladiorum* and *crusta* the words *Unde Cicero.* Whether they belong to the words immediately preceding, and were intended to introduce an illustration, or to some sentence lost, I am not able to say.

55. *Hilarum.* This article is in the Cod. Vat. only. The neuter form of the adjectives and participles is to be noticed. Whence the definition is taken I do not know.

After this brief examination of the several articles of the fragment, some general considerations on the plan, age, and sources of Petronius suggest themselves. The first is as to the plan and object of the author in making his compilation. It appears most probable that the compilation owes its existence to the circumstance that the author, in the course of his reading, made notes of such expressions as seemed to him of interest, and that whatever traces of a plan or systematic arrangement may be discovered are owing to the plan or order of reading pursued by the author, rather than to the intention of furnishing a glossary arranged according to some system. The fifty-five articles of which the collection consists may be divided into the following seven classes: —

I. Natural History: 1, Nitrum; 2, Choirogryllus; 3, Capparis; 9, Coloquintis; 50, Dipsas.

II. Technical Terms: 4, Epinicia; 5, Exedrae; 6, Scalptura; 7, Mulsum; 8, Peribolus; 10, Classica; 11, Synaxis; 12, Anaglypha; 14, Carpasinus; 15, Lorica; 16, Rheuma; 17, Scutra; 18, Amullae; 19, Catalogus; 31, Intra Kalendas.

III. Hebrew Terms: 13, Musach; 52, Iobel.

IV. Etymological: 20, Avarus; 21, Locuples; 26, Priva; 27, Italia; 28, Elegantia; 30, Lictorem; 33, Humanitas; 35, Faciem; 36, Profligare; 37, Vestibulum; 38, Vescum; 39, Foenerator; 40, Assiduus; 42, Soror; 43, Frater; 44, Humilitas; 45, Mansuetudo; 46, Devotio; 47, Misericordia; 48, Pax; 49, Luctus and Dolor; 53, Peta; 54, Crusta.

V. Political Terms: 22, Lex; 23, Populus; 24, Plebs; 25, Plebiscitum; 32, Pomerium.

VI. Synonymes: 29, Mendacium and Mentiri; 34, Manubiae and Praeda; 55, Hilarum.

VII. Grammatical: 41, Quin; 51, Adeo.

In several of these classes, especially the fourth, traces of a regular series, although with some exceptions, are perceptible. If we unite the last five classes — the third, fourth, fifth, sixth, and seventh — into one group, calling it the linguistic, and the first two into another, the realistic, we have two nearly complete series, the regularity of which is disturbed by two expressions only, viz.: 31, Intra Kalendas, and 50, Dipsas, which belong to the first instead of the second series. Whatever importance may attach to these traces of a regular arrangement, it is certain that the compiler aimed neither at perfect regularity nor completeness. Even a glance shows that there is no attempt at an alphabetical arrangement.

As to the age of the compiler, a late period must undoubtedly be assigned to him. Both the language and contents of some of the articles point to Christian sources, and if these are the writings of such men as Hieronymus and Augustinus, as appears probable, the author of our fragment, whether his name be Petronius or not, cannot be placed earlier than the end of the fourth or beginning of the fifth century of the Christian era.

Not the least interesting question, however, relates to the sources of our author, and especially his relation to Gellius furnishes a curious problem. If we examine the arrangement of those words which occur in Gellius as well as Petronius, they form, with one exception, an uninterrupted series of twenty-three words, viz.: 20, Avarus; 21, Locuples; 22, Lex; 23, Populus; 24, Plebs; 25, Plebiscitum; 26, Priva; 28, Elegantia; 29, Mendacium; 30, Lictorem; 31, Intra Kalendas; 32, Pomerium; 33, Humanitas; 34, Manubiae; 35, Faciem; 36, Profligare; 37, Vestibulum; 38, Vescum; 39, Foenerator; 40, Assiduus; 41, Quin; 42, Soror; 43, Frater. The exception referred to is the article 27, Italia, which intervenes between 26, Priva, and 28, Elegantia. It will not be denied that this circumstance is by itself a strong, although not irresistible, argument in favor of the opinion, that Petronius borrowed in all these articles directly from Gellius; that while reading the work of Gellius he copied, with more or less completeness and accuracy, the definitions of Gellius. This view is strengthened by another circumstance, namely, that Petronius, with two exceptions, follows in these twenty-three articles the order of Gellius, the two exceptions being the articles 42, Soror, and 43, Frater, which in Gellius occur in lib. 13, 10, earlier, therefore, than the ten preceding articles, from 32, Pomerium, to 41, Quin. Another less important departure from the order of Gellius may be mentioned, viz. 40, Assiduus, which in Gellius precedes, while in Petronius it follows, the article 39, Foenerator.

On the other hand, it should not be overlooked that in some of these articles, as has been pointed out, the agreement between Petronius and Gellius is less striking, and

that Petronius has definitions of some terms which he could not have borrowed from Gellius, because they are not contained in the work of the latter, and that, as he borrowed in these instances from other, perhaps the original sources, he may also have done so in those in which apparently he agrees with Gellius. While, then, the opinion that this portion of our fragment is nothing but excerpts from Gellius rests upon some strong arguments, it is opposed by some not inconsiderable difficulties. But whatever the decision of the question, — whether Petronius borrowed directly from Gellius, or whether both drew from a common source, above indicated in the several articles, — the importance of the fragment of Petronius in establishing, in a few instances, the text of Gellius (for instance, the reading Socrates in the article 41, Quin), remains the same.

Corrected Text.

1. Nitrum dicitur a nitra provincia; ubi si in aestate prolixa pluvia terram infuderit, rapida vis solis aquam concoquit in petram salis et nivi simillimam sed nihil frigoris vel salsi humoris habentem, quae salis more vel caumate durescit vel pluvioso aere liquescit; hoc indigenae ad lavandum utuntur.

2. Choirogryllus, animal non majus ericio simile muri vel urso in cavernis petrarum habitans, in Italia abundans.

3. Capparis, herba quae salitur. Plautus in Curculione: voltisne olivas aut pulmentum aut capparim, et Martialis: Capparin et putri cepas halece natantes.

4. Epinicia, laus de victoria.

5. Exedrae thalami seu cellulae seu potius cubilia aut sedes. Cicero de Oratore: in eadem exedra.

6. Scalptura, quod usitatius sculpturam dicimus; tunc histriaca dicitur; tum qui historias vel gesta aliqua exprimunt, histriones.

7. Mulsum vinum melle decoctum. Plautus in Asinaria: et cantharo mulsum date.

8. Peribolus templi est ipsius circumposita munitionum constructio.

9. Coloquintis agrestis cucurbita et vehementer amara, quae more cucurbitae per terram flagella diffundit; foliorum vero et fructus usualis instar cucumeris. Rotunditas coloquintis nomen dedit.

10. Classica sunt cornua, quae convocandi causa facta erant: et a calando, id est vocando, dicta. Virgilius: Classica iamque sonant.

11. Synaxis concilium vel auditorium vel hora conveniendi dici potest.

12. Anaglypha, celaturae.

13. Musach, sabati arca: ubi reges templum ingressuri eleemosynam imponebant.

14. Carpasinus color est aureus sicut et citrinus.

15. Lorica seu cancellus est murus coenaculorum seu quorumlibet aedificiorum oram ambiens ab iniuria lapsus inibi incedentes defendens.

16. Rheuma est eruptio vel fluor.

17. Scutra sunt vasa aenea aequalis in fundo et ore latitudinis ad calefaciendum vinum.

18. Amullae vero ad offerendum vinum vasa aenea esse dicuntur.

19. Catalogus, ordinarius sermo.

20. Avarus quasi avidus aeris; est litera in iunctura detracta, vel forsitan simplex derivatum ab aveo.

21. Locuples est, qui pleraque tenet loca, id est multas possessiones.

22. Lex est generale iussum populi aut plebis rogante magistratu.

23. Populus est omnis pars omnisque ordo civitatis.

24. Plebs vero ea dicitur, in qua gentes patriciorum non insunt.

25. Plebiscitum est lex illa, quam plebs non populus scivit.

26. Priva dixerunt antiqui, quod nos singula dicimus: unde privilegium, quod non ab universis civibus sed a singulis conceptum visumque est fieri. Inde etiam translative singulares specialesque cuiusque dignitatis eius privilegia appellamus. Haec omnia generali nomine rogationes appellantur: et confuse per se invicem haec ponuntur.

27. Italia dicta est, quod in ea magna boum copia fuerit, qui graeca veteri lingua itali vocitati sunt.

28. Elegantia apud veteres non de amoeniore ingenio sed nitidiore cultu ac victu dicebatur: nec in laude nec in vitio ponebatur. Unde M. Cato in libro, qui inscribitur Carmen de moribus: Sumptuosus, cupidus, elegans vitiosus irritusque habebatur. Unde apparet elegantem dictum antiquitus non ab ingenii elegantia: sed qui nimis lecto amoenoque cultu victuque esset. Postea elegans vituperii desiit esse; sed nulla laude dignabatur, nisi cuius elegantia erat moderatissima.

29. Qui mendacium dicit, fallitur. Qui mentitur, ipse non fallitur; alterum fallere conatur.

30. Lictorem dicit Valerius a ligando appellatum esse; eo quod cum magistratus populi romani virgis quempiam verberari iussisset, crura eius ac manus ligari a viatore solitae sunt. Is, qui ex collegio viatorum officium ligandi habebat, lictor est appellatus. Tiro vero lictorem a lino vel a licio, quod idem est, dici scripsit. Licio enim transverso, qui ministrabant, inquit, magistratibus, cincti erant.

31. Intra Kalendas dicitur fieri, quod non ante Kalendas sed in Kalendis est; id est eo ipso die, quo Kalendae sunt.

32. Pomerium est locus intra agrum effatum populi romani per totius urbis circuitum pone muros regionibus certis determinatus, qui facit finem urbani auspicii.

33. Humanitas proprie est eruditio institutioque, quas in bonas artes dicimus; quas qui sinceriter capiunt appetuntque ii sunt maxime humanissimi. Huius enim scientiae cura et disciplina ex universis animantibus uni homini data est; ideoque humanitas est appellata.

34. Manubias quidam praedam, quae manibus capta sit, appellari existimant. Sed omnino aliud est praeda, aliud manubiae. Nam praeda dicuntur corpora, quae capta sunt; manubiae vero appellata est pecunia a quaestore ex venditione praedae redacta.

35. Faciem hominis quidam putant esse os tantum et oculos et genas, cum facies sit modus et factura quaedam totius corporis a faciendo dicta, ut a specto species et a fingendo figura. Unde Pacuvius faciem hominis dixit pro statura: Aetate, inquit, integra, feroci ingenio, facie procera virum. Nec solum hominum sed etiam rerum cuiuscunque modi aliarum facies dicitur. Nam et montis et maris et coeli facies dicitur.

36. Profligare est deperdere et destruere.

37. Vestibulum a ve particula, quae tum intensionem tum minutionem significat, et a stando componi videtur. Qui enim amplas domos antiquitus faciebant, locum ante ianuam vacuum relinquebant, qui intra fores domus et vias medius esset. In eo loco, qui dominum eius domus salutatum veniebant, priusquam admitterentur, consistebant, sed neque in via neque intra aedes erant. Ab illa ergo grandis loci constatione quasi quadam constabulatione supra dicta spatia vestibula sunt appellata.

38. Vescum quoque ex ve particula et esca compositum et diminutionis vim capit. Aliter enim Lucretius vescum salem dicit ex edendi intensione. Aliter Lucilius appellat cum edendi fastidio.

39. Foenerator a foenore. Foenus a foetu dictum aiunt, et quasi a quadam foetura pecuniae parientis atque crescentis.

40. Assiduus ex ad et sedeo, vel asse et dando, et ita frequentem vel locupletem significat.

41. Quin coniunctio aliter dici putatur cum quasi increpantes vel exhortantes dicimus, ut quin venis, quin legis. Aliter cum dicimus: non dubium est, quin M. Tullius sit eloquentissimus. Aliter cum sic componimus, quod quasi priori videtur contrarium: Non idcirco causam hanc non defendit Socrates, quin utile et honestum existimarit.

42. Soror dicitur quasi seorsum in hereditate non mansura.

43. Frater quasi fere alter.

44. Humilitas secundum quosdam est modestia mentis, quae non effertur supra se in elationem. Secundum vero consuetudinem Latinorum est popularis quaedam ignobilitas seu deterrimum quod Graeci dicunt.

45. Mansuetudo est manuum assuetudo; ut puta cum quae natura fera sunt, manu tractari possunt.

46. Devotio est post defaecatam vitiorum rubiginem purum boni desiderium.

47. Misericordia est affectus subveniendi ex compassione proximi consurgens, munditia cordis nec praesentium delectatione nec praeteritorum recordatione.

48. Pax diversam habet significantionem; aliter enim cum significat requiem animi; aliter cum propitiationem. — Pax est requies animae interiorum bonorum consideratione. — Luctus vel dolor est vivificatio mentis ex primo sensu boni vel mali consurgens.

49. Dipsas genus aspidis est graecae, quae latine dicitur situla. Quemcunque haec momorderit, siti perit; quae adeo est parva, ut cum calcatur, non videatur; cuius venenum ante extinguit quam sentiatur, nec tristitiam sentiat moriturus.

50. Adeo particula, quae aliquando adverbii loco ponitur, ut Virgilius: Non obtusa adeo gestamus pectora Poeni. Rursum pro etiam ponitur, ut Senatus et adeo populus. Ponitur etiam pro coniunctione completiva.

51. Iobel graece id est dimittere. Unde Iobileus id est remissus.

52. Peta impetus gladiorum.

53. Crusta est glacies.

54. Hilarum, laetum, iocundum, ridens, plaudens, gaudens, gestiens.

NOTE 1. — Page 3, read *Anagliffi* for *Amagliffi*.

NOTE 2. — Page 8: χοιρόγρυλλος. Professor Sophocles suggests that the correct form of the word is χοιρογρύλλιος. The weight of evidence is unquestionably in favor of this form. The LXX. has χοιρογρύλλιος, and Hieronymus gives this explanation: "Animal non maius hericio habens similitudinem muris et ursi: unde et in Palaestina ἀρκτομῦς dicitur." Suidas s. v. γύλιος says: ἔστι δὲ καὶ ζῷον ὁ καλούμενος χοιρογρύλλιος. On the other hand, we find in Suidas, s. v. γρύλλος: καὶ γρύλλος ὁ χοῖρος, and in a scholion to Aristoph. Pax 520: (πλέκος) ἔστι δὲ ζῷον ὃ καλεῖται ὑπό τινων χοιρογρύλιος· ἔστι δὲ ζῷον οὗ μέμνηται Σώφρων Ἡράκλεις πνῖγος γύλιόν τι· ἔστι δὲ ὁ καλούμενος ὑπό τινων χοιρόγλυος (χοιρόγριλλος); which passages seem to indicate that the termination of the word was not uniform. This, taken in connection with the circumstance that both manuscripts, however different in other respects, agree in the form of the termination, led me to adopt the form χοιρόγρυλλος.

II.

On the Alloys of Copper and Zinc.

By FRANK H. STORER.

(*Communicated November* 9, 1859.)

This research was undertaken in order to ascertain what, if any, definite chemical compounds could be detected among the alloys of copper and zinc.

Several chemists had already been led to believe in the existence of two or more definite alloys, and at the commencement of my own labors I was strongly inclined to accept this view. A more extended investigation, however, has convinced me that no such definite compounds exist. On the contrary, I am confident that all the alloys of copper and zinc are simply isomorphous mixtures of the two metals, capable, as I shall proceed to show, of crystallizing at any point, from copper with only a trace of zinc, down to alloys containing but thirty per cent of copper, or even less, under favorable circumstances.

The misconceptions of previous observers* have evidently arisen either from the great tendency to separate into layers, instead of immediately forming a homogeneous mixture, which the metals exhibit when fused together; or from certain striking

* I must in this connection refer to, and except, the valuable memoir of Karsten (vid. Karsten u. v. Dechen's *Archiv für Mineralogie, u. s. w.* 1839, XII. 385), whose conclusions in regard to these alloys appear to be perfectly correct, with the exception of a few unimportant details. As is the case with the able research of the elder Mallet, the details of which are to be found only in the Report of the Tenth (Glasgow) Meeting of the British Association for the Advancement of Science, p. 258, the very meagre abstracts of this memoir which are given in the chemical journals and text-books fail to convey a correct idea of the results which have been obtained, — a fact which may serve to explain the ignorance which has been exhibited in regard to them by subsequent experimenters.

peculiarities of structure and of superficial coloration which occur among the different alloys. To these points I shall again allude.

The method which I have used in preparing the alloys has varied slightly according to the amount of copper contained in them. Those in which the proportion of copper was large were prepared by projecting granulated zinc by small portions into the molten copper, the crucible which contained it having been previously removed from the fire, the mixture being thoroughly stirred after each addition of zinc. This method succeeds very well when only a small amount of zinc is to be combined with the copper, perfect combination of the metals being readily obtained while the loss of zinc from volatilization, though considerable, is, if proper care be exercised, much less than would be at first sight supposed. But for alloys containing even as much as 50 or 55 per cent of zinc, this method becomes uncertain.

It is in this case necessary to bring the copper to a high degree of heat before adding the zinc; yet in spite of this precaution, and of the utmost care in adding the zinc only by small portions, which have previously been made as hot as possible, the mass contained in the crucible will often become chilled, and require to be again placed in the furnace in order to be remelted. Since the portion of zinc last added remains uncombined with the copper, and exposed at the surface of the mass, a great deal of it is lost during this operation.

In preparing alloys containing more than 50 per cent of zinc, I have melted the copper and zinc in separate crucibles, and have subsequently poured the zinc upon the copper. It is necessary to remove from the fire the crucible which contains the latter, and to cover it carefully, with the exception of a small opening through which the zinc may be poured; for violent ebullition and projection of particles of the melted metal occur during the first moments of combination. After thorough stirring* in either case, the mass was allowed to cool until a crust had formed on the surface of the alloy. This crust was then pierced, and the fluid matter beneath it poured out. The cup thus formed, having been removed from the crucible, was sawed in two, and portions of the crystals upon its sides cut off by means of a cold-chisel, for analysis. The sheets obtained from the fluid alloy poured off were also retained, and were subsequently analyzed.

The weight of alloy obtained in each experiment varied from two to six pounds. By operating in the manner described, it is easy — especially after a little practice

* I have found that a rod of soapstone eight or ten inches in length, cut somewhat tapering towards its point, screwed into a piece of ordinary one-inch iron gas-pipe, forms a very convenient stirrer. It should be ignited to expel moisture before being used.

has enabled one to judge when the crust is ready to be pierced — to obtain perfect cups lined with well-formed crystals.

The chief difficulty which presents itself depends upon the fact that the alloys containing more than 80 to 85 per cent of copper solidify much more rapidly on top than upon the sides or at the bottom of the crucible. It is therefore necessary to allow a very thick crust to form before piercing, or no cup at all will have been formed, and the alloy will flow out entirely in the fluid state, with the exception of the upper crust.

Fine cups are formed by all the alloys between 80 and 45 per cent of copper, the largest crystals being obtained when the crust is pierced while still quite thin; while the white alloys containing less than 40 per cent of copper solidify, if anything, more rapidly on the sides and at the bottom of the crucible, rendering it necessary to pour out what alloy is still fluid almost as soon as a crust begins to form on top. All the white alloys are liable to pass suddenly into a pasty plastic state similar to that assumed by zinc or by soft-solder while solidifying. On account of this peculiarity, it is exceedingly difficult to crystallize them. I have succeeded, however, in obtaining crystals of alloys as low down as 30 per cent of copper, and have no doubt that, by repeated trials, they might be obtained from alloys still richer in zinc.

These crystals are all octahedral, usually somewhat elongated and apparently much modified by the circumstances in which they have been formed. The edges of all of them are rounded. The octahedra are in general more largely developed upon one side than upon the other, apparently upon the side from which the last drippings of the melted metal fell. They are, moreover, combined together with parallel axes, which give to the crystals a striated appearance (see Figs. 1, 2, and 3); these striæ are not sharply defined, but their edges have the rounded character of the edges of the crystals. This general character is maintained throughout the whole series of crystals, from those of pure copper down to those of the lowest white alloys which I have obtained. No doubt can possibly be entertained of the complete resemblance of these crystals to each other throughout the series, while the striking similarity to the well-known crystals of pure copper (obtained by fusion) which they exhibit, strongly indicates that they belong to the regular system. As it is of course impossible to measure the angles of such crystals, they cannot be crystallographically determined; but the most obvious conclusion is, that they are monometric. This opinion, however, must be based rather upon analogy than on any distinct measurements.

Upon the assumption that the crystals which I have described belong to the

regular system, as well as upon the fact, which will appear in the sequel, that none of the crystals have been found to contain any larger quantity of either of their component metals than was contained in the remainder of the molten liquid from which they had separated, I have based my conclusion that the alloys of copper and zinc are isomorphous mixtures * of the two metals.

On this hypothesis it is of course presumed that both copper and zinc are capable of crystallizing in the regular system. Copper, as is well known, always occurs in forms of the monometric system. But in regard to zinc this has not been so satisfactorily proved. Not only, however, does analogy indicate that zinc should be monometric, — for, so far as is known, all the metals of the Three Series of Cooke † allied to it crystallize in forms of this system, — but Nicklès ‡ has actually observed an instance in which it occurred in the form of pentagonal dodecahedrons.

I am well aware that this is an isolated example; that the angles of the crystals were not measured. It is not to be supposed, however, that a chemist so well versed in crystallography as M. Nicklès could have been mistaken regarding the form of his specimen. We know, moreover, from the analyses of Favre, § that the zinc was almost absolutely pure. Gustav Rose ‖ has urged against this observation, that the form of the crystals is an improbable one, since no other instance is known of a metal crystallized in pentagonal dodecahedrons. I cannot myself perceive the force of this argument; few facts are more thoroughly established, than that the crystalline form of bodies may be largely modified by the influence of the circumstances under which they are formed, — witness, for example, the crystals of common salt obtained from solutions containing organic matter, ¶ — while almost all the crystals of metals with which we are acquainted have been prepared by a single process, — igneous fusion.

Rose has also maintained that the crystals of Nicklès are similar to the rounded or irregularly crystallized masses formed in an atmosphere of zinc vapor which he

* It must not be supposed that this view supports in the least the idea of the older chemists, that alloys were mere "mixtures" of their component metals. For the experiments of Karsten (*loc. cit.*, S. 398, 400) have already shown that the comportment of the alloys of copper and zinc towards acids, and the solutions of various metallic salts, is that of chemical compounds, being entirely unlike that of a simple mechanical mixture of the two metals, or of a mixture of several alloys.

† Memoirs of American Academy, (New Series,) V. table to p. 256.

‡ Ann. Ch. et. Phys., (3.) XXII. 37.

§ Ibid., X. 170.

‖ J. pr. Chem. (N. F.) LV. 292.

¶ Vid. Robin et Verdeil, Traité de Chimie Anatomique, (Paris, 1853,) II. 198, *et* Atlas, pl. 1.

has himself obtained from the receiving-vessels of the Silesian zinc furnaces, and which are, for that matter, familiar enough to those who have often had occasion to fuse zinc in covered crucibles. I would, however, suggest, that the circumstances under which these *mammelons* are formed are by no means identical with those in which Nicklès's crystals were prepared,* viz. in an atmosphere of hydrogen, at a lower heat, and doubtless with less rapid volatilization.†

On the other hand, the very fact which I have myself observed, namely, that most, and probably all, alloys of copper and zinc may be crystallized in octahedrons, is in itself strong presumptive evidence that zinc is capable of assuming a similar form. Indeed, in the absence of any marked tendency in these alloys to separate by eliquation, there remains no hypothesis other than that of isomorphous mixture by which to explain their composition.

* Vid. Jacquelain, Ann. Ch. et Phys. (3.) VII. 204; and Favre, *loc. cit.*

† I have endeavored to defend Nicklès's observation, the more especially because it is certainly as well entitled to be received by chemists as the experiments of Noeggerath (Pogg. Ann. XXXIX. 323) and Rose, which go to prove that zinc may crystallize in forms of the hexagonal system. Neither of these observers has analyzed the crystals which he has described, all of which were accidental products of smelting-works. Now we know from the researches of Cooke (Memoirs of the American Academy, New Series, V. 353; also, Am. J. Sci. (2.) XX. 225), that zinc, which contains only three or four per cent, and probably even a smaller quantity, of antimony, has a strong tendency to crystallize in the form of rhombic prisms of the compound $Sb\,Zn_3$ with excess of zinc. We have also the statements of Laurent and Holms (Ann. Ch. et Phys. 1835, (2.) LX. 333), that zinc containing three or four per cent of iron crystallizes in rhombic prisms; and of Warren de la Rue (Phil. Mag. J. (3.) XXVII. 370; also, J. pr. Chem. (N. F.) XXXVII. 126), who has obtained and measured rhombic prisms of composition,—

Zinc	90.00
Iron	2.56
Lead	6.00
Copper	1.44
	100.00

A. Erdmann (Berzelius, Traité, II. 620) also has analyzed acicular crystals of zinc which were detached from a bit of distilled zinc which had been used to decompose a quantity of chloride of silver. These needles contained,—

Zinc	93.193
Iron	6.524
Lead	0.283
	100.000

In view of all these data, showing the very great influence which the presence of a small amount of impurity may exert upon the crystalline form of zinc, the importance of the fact that we have no evidence whatsoever of the purity of the crystals described by Noeggerath and Rose is manifest.

I must observe in this connection, that G. Rose* has quite recently described a specimen of crystals, labelled "*Mengepresse*," — a term applied to an alloy prepared from one pound of copper from Lauterberg, and two pounds of calamine, — which exists in the Royal Mineralogical Museum at Berlin, having been obtained from the collection of Klaproth. These crystals, in the opinion of Rose, appear to belong to the monometric system; but since Prof. Rose has published no analysis of them, we not only have no clew to their probable quantitative composition, but are left in doubt whether they are really a compound of copper and zinc; though the facts which I have here brought forward render the supposition an extremely probable one.

Notwithstanding this, and in spite of the fact that his alloy is only a single isolated example, Rose has urged, in direct opposition to his previons opinion, that it proves that zinc must belong to the regular system. In point of fact, however, the observation of Rose, taken by itself, evidently proves nothing of the kind. For, admitting that his crystals are really brass, he has offered no evidence to show that they do not belong to one of several possible definite alloys; only after proving that such crystals do occur through the whole series of alloys, as I have shown is really the case, and demonstrating that no definite compounds exist, could the idea of isomorphous mixture be entertained.

The crystals obtained by myself vary in size; some of them being more than half an inch in length, while others are quite minute. In general they are smallest in those instances where the greater part of the alloy had solidified before the crust was pierced.

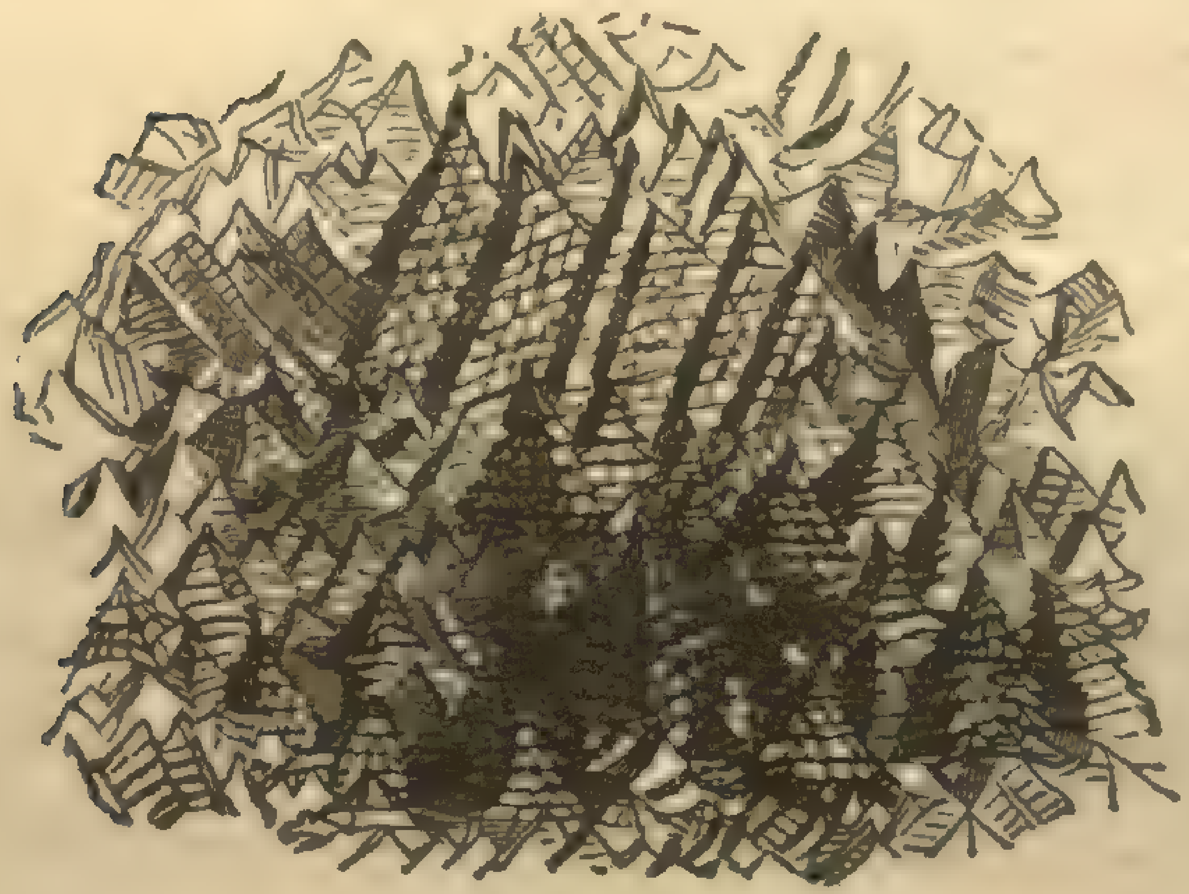

Fig. 1.

Fig. 1, which is a copy of a portion of the crystalline crust, from the alloy containing 94.38 per cent of copper, may serve to give a general idea of the character of these crystals.

In a few of the specimens of alloys, the crystals have exhibited a tendency to assume a somewhat tabular form, — a single face of an octahedron being largely developed, to the exclusion of the other faces, as may be seen in Fig. 2, *a*; while in other specimens separate individual crystals have occurred, Fig. 2, *b* and *c*. Both of these peculiarities presented themselves in the alloy of 83.72 per cent of copper, portions of which are represented in Fig. 2.

* Pogg. Ann., July, 1859, CVII. 448.

As a rule, however, all of the crystals obtained closely resemble those delineated in Fig. 1. Indeed, this figure might be used to represent almost any specimen in the long series of alloys which I have prepared. Very fine groups of crystals were obtained from those alloys which contained only one or two per cent of zinc. It is worthy of note, that, although these crystals have the same form and general appearance as those prepared by the same method from an equal quantity — three or four pounds — of pure copper, they are nevertheless much larger and more perfect. Since they may, for all practical purposes, be considered as crystals of copper with slight impurity of zinc, and are easily to be obtained, it would almost seem advisable to add one or two per cent of zinc to the metal employed in preparing specimens of crystallized copper for the cabinet. A similar case is presented by lead, which is very readily crystallized when it contains a little antimony: a fact well exemplified by the beautiful cups of crystals of *Krätzblei* which are prepared by partially cooling the metal in ladles, at the Frankensharner smelt-works near Clausthal, and doubtless at other localities in the Hartz.

Fig. 2.

Since the crystals rich in copper which have just been described do not possess in any marked degree the yellow color peculiar to brass, they are somewhat less interesting than those obtained from alloys containing more zinc. Crystals of the latter can be obtained with the greatest ease by remelting old brass, or, better, by filling a Hessian crucible from the molten metal of the pots of a brass-founder, in which case all annoyance from the formation of a false crust of mixed oxide of zinc and metal is obviated. I mention these details, because I have myself found it somewhat difficult to acquire the knack of obtaining at will good crystals, when the alloys were prepared directly from the pure metals; having frequently been compelled to repeat a single experiment three or four times before satisfactory results were obtained. This is owing to the different degrees of rapidity with which the alloys cool, a fact to which I have already alluded.

The most perfect individual crystals were obtained from a quantity of brazier's solder which had been prepared at the foundery of the Revere Copper Company in Boston by fusing together 50 parts of copper with 50 parts of zinc. When an alloy of about this composition solidifies, and especially if it be suddenly cooled, — as happens when it is poured into iron ingot-moulds, — it assumes, as is well known, a highly crystalline structure, consisting almost entirely of a mass of coarse fibres

which shoot out from the points at which the alloy comes in contact with the cold metal of the mould. In the instances which have fallen under my notice, the ingots being from an inch to an inch and a half in depth, the fibres have shot up three quarters of an inch, or more, from the bottom of the ingot, leaving only a sheet of metal about a quarter of an inch in thickness on top, which had cooled more slowly by contact with the air.

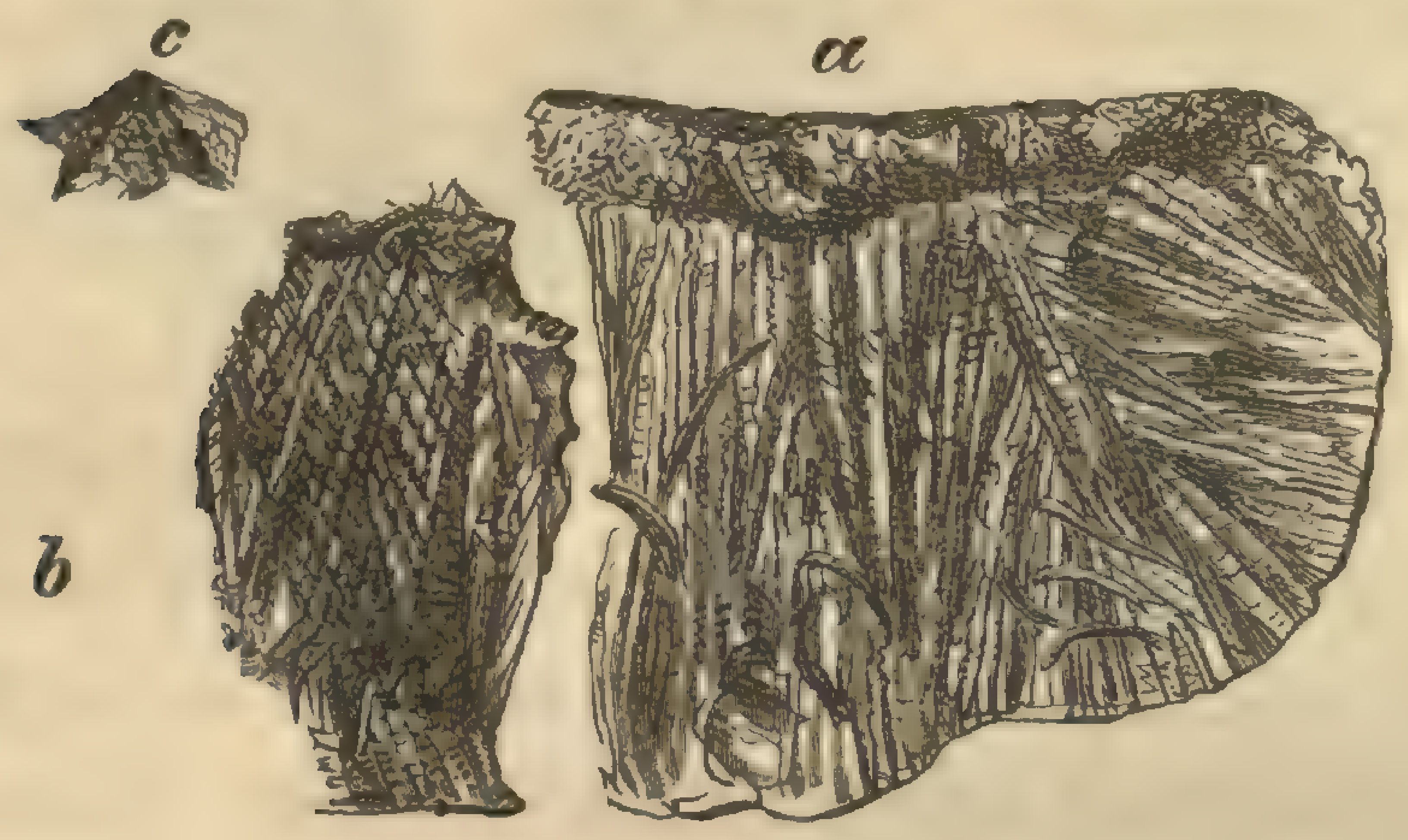

Fig. 3.

Fig. 3, *a*, represents in section a fragment of one of these ingots. One side — seen at the right — as well as the bottom of the portion figured having been in direct contact with the iron mould in which the ingot was cast, the crust just alluded to may also be seen above the fibres. On removing portions of this upper layer, its inferior surface will be found studded with crystals, often of great beauty, — Fig. 3, *c* conveys but an imperfect idea of a portion of one of these, — while others frequently occur impacted among the fibres themselves. Indeed, these fibres, although described by Calvert and R. Johnson * as prismatic crystals, indicating that the alloy Cu Zn is a definite chemical compound, are evidently nothing more than collections of octohedral crystals, similar to those which form the fibres of sublimed sal-ammoniac and of several metals.†

By comparing the striations on these fibres with those upon any of the crystals of the series, it is impossible to resist the conviction that the former are mere aggregations. This conclusion is confirmed by the fact that the individual crystals which have been just mentioned as occurring above and among the fibres are evidently parts of the same system as the latter. Fig. 3, *b* represents a portion of one of the fibres somewhat magnified. It often happens that this alloy, known as brazier's solder, is run into cylindrical moulds of two or three inches in diameter, pierced in earth; in this case the fibres shoot out from all sides towards the centre, leaving at the middle of the bar a sort of neutral ground in which tolerably well-formed crystals frequently occur. The solder is prepared for market by warming it slightly, ‡

* Journal of the Franklin Institute, (3.) XXXVII. 200. See also Philosophical Transactions, Vol. CXLVIII. p. 367.

† *Vid.* Savart, Annales de Chimie et de Physique, (2.) XLI. 65.

‡ It must not be heated above a very moderate temperature, for, like metallic zinc at certain temperatures, it then becomes somewhat tenacious or pasty, and cannot be powdered.

and then pounding it in an iron mortar till it is reduced to a somewhat coarse powder. With the fibres, this result is easily obtained, since no great effort is necessary to tear asunder the numberless little crystals of which they are composed; but the larger individual crystals which occur in the crust and core, as just described, are much more refractory; they are removed from the finer powder by sifting, and are subsequently remelted. Among these rejected "kernels" very good crystals may often be found.

The tendency to shoot out into fibres, which has been alluded to, and which deserves something more than a passing notice, extends over quite a space, from alloys containing 57 or 58 per cent of copper, or even more, down to those containing 43 or 44 per cent, where it gradually disappears, as I have proved by casting a series of ingots. Although it does not altogether prevent one from obtaining crystals by the method of pouring off the still fluid portion of the alloy from that which has been allowed to solidify, still the crystals which I have obtained in this way within the limits of its influence are in general less perfect than those of the alloys containing more copper; indeed, on remelting the solder from which the finest separate crystals were obtained, and pouring off a portion of it after the rest had become solid, only indifferently good specimens could be procured. The alloy appearing to pass so quickly from the liquid to the solid state, that the crystals have but little time in which to form. It is remarkable that this inclination to form fibres is strongest in those alloys which contain nearly equal equivalents of zinc and copper, being less clearly marked as one recedes in either direction from this point, until a stringy texture analogous to that of copper is reached on the one hand, and the peculiar pastiness of zinc on the other. In preparing crystals, this pastiness manifests itself decidedly in the alloys immediately below those which are fibrous, becoming more strongly marked as the alloys are richer in zinc;—at least, so far as my own experiments have extended, i. e. to 30 per cent or less of copper. The fracture of these white alloys is for the most part vitreous. The pasty condition appears to depend to a certain extent on the manner in which the alloy is cooled, being less apparent when this process has been rapid. I have repeatedly obtained fine cups lined with tolerable crystals from alloys, which in other trials afforded nothing but a mass of paste. The transition, however, from complete liquidity to the pasty condition, when the latter is assumed, is very rapid.

The fact that the alloys just mentioned take on the fibrous texture when cooled under ordinary circumstances has, moreover, a very important practical bearing;—alloys at the upper limit of this fibrous tendency being the lowest—i. e. richest in zinc—which can be rolled or subjected to the various processes by which metals

are wrought. Singularly enough, at a point just beyond the limit at which the fibres cease to be apparent, viz. at 60 per cent of copper, an alloy of peculiar homogeneity occurs; — its fracture, as seen when small bars are broken, being smooth and compact, and entirely unlike either the coarse, irregular, stringy fracture of alloys richer in copper, or that of alloys containing only a little more zinc, upon the fracture of which small bundles of fine crystalline fibres are often apparent.

This alloy readily admits of being rolled, either hot or cold, and may be subjected to the operations of hammering or drawing without detriment, while alloys containing only a few per cent more copper can be rolled hot only when the sheets are raised to a very high temperature. Even then it is exceedingly difficult to obtain thin sheets without cracking their edges.

On the other hand, alloys containing somewhat less than 60 per cent of copper cannot well be rolled hot, since, when the ingots are heated, the exterior — especially at the corners — is liable to become pasty before the centre is soft enough to admit of being rolled.

In the preparation of the alloy of 60 per cent of copper, now so extensively used for sheathing vessels, under the name of Muntz's sheathing or yellow-metal, — also known as malleable brass, — it is the custom of founders to reserve a portion of the zinc which has been weighed out for a charge, until the alloy in their pots or furnace has become sufficiently hot; * the last portions of zinc are then added in small pieces, a sample of the alloy being tested after each such addition. This is done by dipping out a small portion of the melted mass and pouring it into a mould; a little ingot, five or six inches long by an inch or less in thickness, is thus obtained, which, after cooling, is broken on an anvil, and its fracture observed. If this does not exhibit a smooth and homogeneous surface, more zinc is added to the alloy. The accuracy with which an experienced workman can thus obtain the desired alloy is truly astonishing, the more especially since this homogeneous alloy is confined within very narrow limits.

It is stated by founders that the alloy of 60 per cent of copper and 40 per cent of zinc will present almost precisely the same homogeneity of fracture, whether the test ingot prepared from it be cooled slowly, by exposure to the air, or rapidly, by plung-

* The temperature to which the alloy is brought before pouring is considered to be a point of much importance by founders. In their opinion, a very inferior alloy would be formed if it were not heated much more strongly than would be necessary to maintain it in the liquid state. Compare Bolley, *Zur Kentniss der Moleculareigenschaften des Zinks*, Ann. Ch. u. Pharm., XCV. 302. This subject is evidently connected with the phenomena of tempering described in another part of this memoir.

ing it into cold water, while alloys containing either more or less than 60 per cent of copper are liable to assume different structures, according as they are cooled with greater or less rapidity. Two ingots are therefore sometimes cast, on each trial of the alloy, one of which is cooled in water and the other in air, for comparison. This double test is, however, deemed superfluous by skilful workmen.

I may remark, in this connection, that I have repeatedly obtained crystals, by the method of partial cooling, from portions of melted yellow-metal taken from the founder's pots at the moment it had afforded them a satisfactory test. These crystals are in no wise different from those obtained by myself from alloys of almost identical composition.

Although, as has been stated, the tendency to form fibres seems to have ceased at the alloy containing 60 per cent of copper, I cannot but think that the limit of its influence is less clearly defined than the "test" of yellow-metal founders would seem to indicate. In the circumstances under which this test is applied, it is doubtless true that no fibres are formed; but it is a matter of experience with manufacturers of yellow-metal, that the texture of the large ingots from which the sheets of sheathing are rolled is no longer so homogeneous as that of the small test ingot; they affirm also that this texture may vary greatly, according to the conditions in which the ingot is allowed to cool. It is evident, therefore, that during the processes of hot and cold rolling, and of annealing, to which the alloy is subsequently subjected, its texture may undergo various changes; while it is certain that the comparative durability of the sheathing, when exposed to the action of sea-water, must in great measure depend upon its relative compactness. If it be open and porous, as would be the case if a trace of the fibrous structure were present, it is clear that the sheathing would soon be destroyed; — not only because the salt water would come in contact with its interior portions, but also since the individual crystalline fibres of the alloy would doubtless resist its action more completely than the amorphous matter attached to them or contained in their interstices; from this a galvanic action would be produced, which could not fail to promote the corrosion of the alloy.

One of the most common complaints against yellow-metal arises from a tendency which some specimens of it exhibit to become so friable, after an exposure of longer or shorter duration to sea-water, that the sheets may readily be broken in pieces, sometimes even between the fingers. Attention has recently been called to this subject by Bobierre,* who would refer such cases more particularly to chemical

* Thèses présentées à la Faculté des Sciences de Paris.

Thèse de Physique: Des Phénomènes électro-chimiques qui caractérisent l'Altération, à la Mer, des Alliages employés pour doubler les Navires. Nantes: Imp. Busseuil. 1858. p. 61.

conditions depending, as he thinks, upon the too great proportion of zinc which is used in the preparation of the alloy, yellow-metal, as well as to changes of composition produced by hot rolling.

I cannot agree with this conclusion. In my own opinion, the other alternative which Bobierre has suggested, namely, peculiar arrangement of the molecules of which the alloy is composed, furnishes the true explanation of the difficulty. It is, however, possible, that at times, when the temperature of the reverberatory, in which the alloy is heated before passing to the rollers, is not properly regulated, zinc may be burned off from the exterior portions of the sheet, and that the alloy richer in copper which would thus be formed may subsequently be pressed into the body of the sheet during the operation of rolling. An alloy destitute of homogeneity would result from this treatment which could hardly be durable in any event. Instances of this sort must nevertheless be rare, for no part of the process is watched by the manufacturers more scrupulously than this.

It must also be borne in mind, that, of the enormous quantity of yellow-metal which is now used by the merchant-vessels of Great Britain and of this country, — all of which is composed of sixty parts of copper and forty parts of zinc, and rolled hot, — only a comparatively small portion passes into the friable condition to which I have alluded.

In most cases the alteration which the sheathing undergoes is gradual and regular, and the portion which remains after the wear of several years is still malleable. Indeed, the absolute amount of sheathing which becomes friable is entirely out of proportion with the annoyance to which it subjects ship-owners; * for it rarely happens, even in the worst instances, that more than one third of the sheets upon a vessel become friable, the remainder being in good condition.

The friability is therefore a purely accidental occurrence, and by no means a necessary consequence either of hot rolling or of the presence of 40 per cent of zinc in the alloy, as has been implied by Bobierre.† I am strongly of opinion, that it might be in every instance entirely obviated by methodically annealing or tempering

* Whenever the destruction of a portion of the sheathing requires that a ship be hauled up for repairs, it is customary, since this operation is an expensive one, to resheathe the vessel entirely; for as the friable sheets are interspersed among the others, and since all the sheets are somewhat worn, it would be bad economy to attempt any partial repairs. Of course the owner of the vessel regards the entire suit of sheathing as being worn out, and forms his opinion of the durability of yellow-metal in accordance with this view.

† Thèses, p. 77.

the sheets of alloy in such a manner that no fibres could form in them, and that their structure should be homogeneous.

Bobierre, in his very able thesis, to which I have already alluded, has urged that it would be well to discontinue the use of the alloy containing 60 per cent of copper, which admits of being rolled hot, and to substitute for it sheathing prepared from alloys containing about 66 per cent of copper, which can only be prepared by a most laborious process of cold rolling. It is true that the fibres which I have described would in this case probably never be encountered. Still there are several important objections to the proposition of M. Bobierre. Not only would the method of cold rolling consume a much greater amount of time and labor; but it would be exceedingly difficult, if not impossible, to procure any alloy the composition of which could be maintained so nearly constant as is the case with yellow-metal.* It is not probable that a test like the one applied to this alloy could be found anywhere else in the whole series.

It is frequently stated in chemical text-books that yellow-metal is always prepared from "best-selected" copper, and one is led to infer that a metal of peculiar purity is alone used in its manufacture. This may once have been the case; but since the immense increase in the use of this alloy, it would no longer be practicable to obtain a sufficient quantity of copper of uniform character, or indeed of any one kind, from which to prepare the large quantity of sheathing which is used. In an establishment where expense would be a secondary consideration, as, for example, in a government workshop, it might still be possible to prepare an alloy constantly from the same sorts of copper and of zinc, in which case, although the amount of zinc lost would probably be subject to considerable variations, one might, nevertheless, soon be able to control the process, and to prepare an alloy of the composition proposed by Bobierre, so that only trifling variations should occur in the composition of the product. But in ordinary practice manufacturers are compelled to make use of the most varied kinds of copper, not only because the supply of the best sorts is limited, but particularly from the fact, that, owing to the competition which exists between the various founderies, — or rather, by force of the laws which regulate supply and demand, — they are obliged to remelt larger quantities of old copper sheathing,† the origin of which is unknown to them, and which may have been originally prepared from copper of inferior quality.

* An alloy of constant composition might, however, possibly be prepared, by adding known quantities of melted copper to determined volumes of molten yellow-metal which had been prepared by the usual method.

† The popular notion, that a better — "more compact" — product is obtained by *remelting* any alloy, may also have some connection with this custom.

Now since many of the impurities of copper are eliminated when it unites with zinc, being thrown up on the surface of the melted metal as a crust or scum, which is removed by the workmen,* and as no two samples of copper contain the same kind or quantity of impurity, the amount of it removed, or, what is the same thing, the amount of copper left to unite with a given weight of zinc, † must continually vary.

From this it may easily be seen how very difficult, if not impracticable, it would be to obtain anything like constant results, unless some test were found by which the workmen might ascertain at least approximately the composition of his alloy. ‡

That it is of the first importance that every alloy used for sheathing shall possess some one constant composition, so that it may endure equally well on all parts of the vessel, and that no galvanic action may occur between the metal of different sheets, is a point too obvious to be mentioned.

It might still be urged against yellow-metal, that the admixture of other metals — of kinds capable of mingling with it — which may have been derived from the copper used in its preparation, is a serious objection to its use. This is true, and the remark applies with equal or even greater force to all the alloys used for sheathing; it must always depend upon the condition of copper metallurgy. It would apply more forcibly, for example, to the low-grade brass which Bobierre has proposed to substitute for the ordinary sheathing-metal; for since the "test" by means of which founders are enabled to prepare the alloy — yellow-metal — of constant composition cannot be obtained if metals are present which are incapable of mixing in all proportions with this alloy, in which event small particles of the foreign substances would be found irregularly disseminated upon the fractured surface of the test ingot, manufacturers are enabled to ascertain at once whether or no a given sample of copper is suitable for the preparation of yellow-metal. Whenever it is

* This explains the remark of Karsten (*loc. cit.*, S. 386), that perfectly pure copper can take up from 1.5 to 2.5 per cent more zinc than impure, and still afford a product of better color, more tenacious and more malleable.

† Much zinc also is lost in this case, both by alloying with the foreign metal and by uniting with any oxygen which may have been combined with the latter. As the workmen say, impure copper "burns up" a great deal of zinc.

‡ It must be well understood, however, that as a rule manufacturers of alloys of copper and zinc always use the best copper they can obtain, since it is generally more economical for them to do so. For the purer this metal is, so much the greater will be the total amount of alloy obtained by the use of a given weight of it, or, in other words, the loss, mentioned in the preceding notes, which would occur from elimination of impurities, will be smaller.

found that satisfactory tests cannot be obtained, the copper is immediately rejected by the founders, and applied to some other use. No similar means of controlling the purity of the brass in question are known.

It does not appear — at all events it has never been proved — that any serious injury results in practice from the use of the most varied kinds of copper, so long as they afford the desired *homogeneous* alloy containing 40 per cent of zinc.

I do not wish to deny that hurtful impurities may at times occur in yellow-metal, in spite of the test to which I have so frequently alluded. Most probably the very rare cases in which this alloy wears out irregularly, portions of the sheet being much corroded, while other parts are scarcely at all acted upon and have preserved their original color and malleability, may be referred to the irregular diffusion of such impurities throughout the mass of alloy of which the sheet was formed;* but their influence must be regarded as being of very slight importance in comparison with the changes of structure which have already been discussed.

The following is a list of the alloys which I have prepared. Crystals were obtained from all of them, with the exception perhaps of one or two of those lowest in the series, where the tendency to assume a pasty state during solidification renders the crystallization obscure.

The amount of copper contained in both the crystals and the portion of fluid alloy poured off from above them was determined directly by assay in each instance. The copper used in the preparation of the alloys was a very pure article from Lake Superior; it contained only a certain amount of suboxide of copper and traces of silver.

The zinc was from La Vieille Montaigne, containing as its principal impurity a small amount of lead. Both metals were granulated for convenience in weighing. The lead and other impurities have been neglected in stating my results.

* It is not impossible that the small amount of silver which, as is well known, is precipitated from sea-water upon the metallic sheathing of ships, can accumulate to such an extent in yellow-metal which has been repeatedly used and remelted, that the durability of the latter may be seriously impaired thereby. It is, however, equally probable, and perhaps more so, that the greater part of this silver is eliminated in the preparation of the alloy, when the old metal is fused with zinc.

Number of the Experiment.	Per cent of Copper put into the Alloy.	Per cent of Copper found in the Crystals.	Per cent of Copper found in the portion of Alloy poured off.	Number of the Experiment.	Per cent of Copper put into the Alloy.	Per cent of Copper found in the Crystals.	Per cent of Copper found in the portion of Alloy poured off.
1	97.38	99.14	98.68	21*			62.30
2	96.50	95.57	97.40	22	60.29	61.16	61.99
3	94.38	95.06	95.04	23†		60.92	61.36
4	94.38	94.30	93.82	24†		60.77	60.88
5	91.38	90.77	91.49	25‡		60.42	60.24
6	88.38	88.86	88.78	26	56.69	57.82	58.66
7	85.38	86.10	85.74	27	53.09	54.22	54.45
8	79.38	83.72	83.61	28	51.00	52.62	52.11
9	82.38	82.89	82.52	29	49.00	49.51	49.55
10	79.38	80.34	80.73	30	47.00	49.43	48.26
11	76.38	77.32	78.92	31	45.00	47.49	46.79
12	73.38	75.03	74.27	32	43.00	44.41	43.63
13	74.38	75.71	74.94	33*		43.64	44.01
14	72.38	74.52	73.61	34	41.00	41.48	42.19
15	70.00	71.48	71.68	35	39.00	38.57	38.77
16*			69.20	36	37.00	38.09	37.71
17	67.40	68.93	67.37	37	35.00	35.33	36.71
18	65.94	67.12		38	33.00	32.98	32.79
19*		66.94		39	27.31	29.67	29.07
20*		65.56		40*		29.07	

In determining the amounts of copper contained in these alloys I have employed a method which has been used for a long time by many of the copper assayers of this country, by whom it is highly esteemed. It is essentially the old Swedish method § of precipitating the copper from its solution in acid, by means of metallic iron; with, however, several more modern modifications and improvements.|| Since several of the details of this process have never, to my knowledge, appeared in chemical literature, I shall make no apology for describing it at length in this connection.

In choosing samples of the alloy for analysis, I have been careful to select those portions of the cup which were best crystallized, avoiding always the upper crust,

* The instances in which the amounts of metal used in preparing the alloy are not given, refer to crystallized products which were obtained accidentally during the course of the research.

† Yellow-metal from founder's pots, said, from appearance of test ingot, to require a little more zinc.

‡ Yellow-metal which had afforded a satisfactory test.

§ *Vid.* Bergman, Physical and Chemical Essays, translated from the original Latin by E. Cullen, M. D., (London, 1788,) Vol. II. p. 443. Described more fully by Kersten, in Karsten u. von Dechen's *Archiv für Mineralogie, u. s. w.*, XII. 567; also by Kerl, in Bodemann's *Probirkunst* von Bruno Kerl, (Clausthal, 1857,) S. 216.

|| For information concerning these I am indebted to Mr. G. J. Dickinson, chemist of the copper works at Point Shirley, near Boston.

which had lost zinc by volatilization while cooling; from the sheets into which the fluid portion of the alloy was cast, I have taken pieces near the edge, which were free from any admixture of fragments of the crust.

Pieces of the alloy weighing from four to twelve grammes, accordingly as they contained a greater or less amount of copper, which had been carefully cleaned by filing and brushing, were placed in covered porcelain dishes, and dissolved in strong nitric acid on the sand-bath, the usual precautions to avoid loss from spattering being observed. To the solution thus obtained, sulphuric acid — which had been freed from its impurity of lead by dilution with water and subsequent partial concentration — was added, and the mixture evaporated to dryness over the water-bath; more sulphuric acid being added, and the solution again evaporated until all the nitric acid was expelled, or till no trace of blue crystals remained. I have rarely found it necessary to evaporate the solution more than twice in order to effect this.

It is of importance that the nitric acid shall be thoroughly removed, for in the presence even of a mere trace of this acid it is exceedingly difficult to precipitate, by means of iron, the last portions of copper from its solution.

After all the nitric acid had been expelled, the mixed sulphates were dissolved in hot water, and the sulphate of lead (from impurity in the zinc of the alloy) allowed to settle; this was then separated and washed with acidulated water, by decantation.

The solution, which had been collected in a capacious beaker, was now largely diluted with water and placed upon a sand-bath, the heat of which was regulated so that the solution could attain a temperature nearly equal to boiling, without, however, coming into actual ebullition. A sheet of the purest iron obtainable was next placed in the solution, leaning against the sides of the beaker so that the largest possible amount of its surface should be exposed, in order that the iron might be attacked equally at all points by the acid, and that the copper should be precipitated in even sheets upon it.

The solution should be acid enough to insure a slight evolution of hydrogen during the precipitation. Care should, however, be taken to guard, in the first instance, against the addition of too great an excess of acid, lest the iron be corroded to an unnecessary or even ruinous extent. It is of course desirable to avoid dissolving any more iron than is necessary to insure regularity and completeness in the precipitation, for in this case a smaller portion of its impurities will be exposed, and its surface will remain smoother.

After the introduction of the iron, the beaker is to be covered with a glass plate, and left to itself until the copper is entirely precipitated, which occurs at the end of an hour or two at farthest. Having proved that no more copper is contained in the solution by testing a small portion of it with sulphuretted-hydrogen water, the beaker is removed from the sand-bath, and the clear acid solution decanted off as completely as possible from the copper and iron.

If this solution be diluted with a large quantity of hot water, it immediately becomes yellow, then turbid, and in a few minutes deposits a bulky flocculent precipitate of a basic salt of peroxide of iron, although the supernatant liquid is strongly acid. Since a quantity of this solution remains adhering to the metals, it is well, in order to avoid the precipitate which would form if they were treated at once with hot water, first to pour a small quantity of cold water upon them. The piece of iron is then to be taken from the beaker, and any particles of copper which may be loosely attached to it removed by means of the wash-bottle; the iron being carefully preserved for subsequent examination. The copper, having been once more rinsed with cold water, is now to be treated with boiling water, which should be decanted off into a large clean beaker, without waiting for all the copper to be deposited, as soon as the liquor assumes a yellow color. After two or three additions of hot water, the subsalt of iron is no longer precipitated, and the copper may be allowed to subside at its leisure. Any particles of copper which are found adhering to the sheet of iron which was used for the precipitation must now be removed by gently rubbing them with the finger, care being taken not to disturb the black coat* which is found adhering to the iron, any more than can be avoided; they are then to be washed into a small porcelain capsule, into which is also brought the mixed deposit of subsalt of iron and particles of copper collected during the first rapid washing of the copper.

* The black crust which forms on the iron beneath the layer of copper contains a small amount of carbon and some silica, but consists for the most part of what appears to be a compound of silicic acid and oxide of iron; this substance, called Slag by Morfit and Booth in their very able "Report upon the Chemical Analysis of Cast-Iron Gun-Metal," (*vid.* Report of Experiments on Strength, &c. of Metals for Cannon, by Officers of the Ordnance Department, U. S. Army, (Philadelphia, Baird, 1856, 4to,) p. 408,) is but sparingly soluble in dilute chlorhydric acid; slowly soluble in cold, more rapidly in hot concentrated chlorhydric acid; easily soluble in concentrated nitric acid, especially when hot; with separation of silica in both cases. It is slowly decomposed by strong soda lye. This "slag" is formed in considerably larger quantity when sulphuric acid is used than when chlorhydric acid is substituted for it in the assay. As it usually adheres, however, to the iron with considerable firmness, the copper can generally be rubbed off without disturbing it materially.

The contents of the capsule are now treated with dilute chlorhydric acid, in which the subsalt is readily soluble, washed with water, and added to the original copper, the washing of which is to be continued till the last traces of acid are removed. The copper, having been transferred to a porcelain boat, was dried at 100° C., ignited in a current of hydrogen gas, and subsequently weighed.

The iron used in these assays was that known as the "best Russia sheet." In order to obtain the best possible pieces, I have followed the custom of copper assayers in allowing a sheet-iron worker to cut up a number of pounds of Russia sheet into bits of about two and a half by three and a half inches, this size having been found well adapted to the work at hand, smaller pieces being unequally corroded; from this supply only those pieces which presented a perfectly smooth and even surface were selected for use. Those pieces which are at all corrugated or uneven ought to be rejected, for such are acted on unequally by the acid, and copper would be lost in the cavities thus formed.

Since the sharp angles of these rectangular bits of iron are liable to be corroded very much by the acid, in which case particles of iron might drop off and contaminate the copper, it is best to remove them by means of a rasp, and to make the corners round and smooth.

The glazed coating which occurs upon the surface of Russian sheet-iron, and which, according to Wells,* consists of silicate of iron, is readily removed by digestion in moderately dilute chlorhydric acid, in which it soon falls off in flakes. After washing with water, the bits of iron are dried and preserved for use.

In conducting the assay it is of importance that the solution should be dilute, since the precipitation of the copper in this case goes on more regularly, and is sooner completed; it should be warm, not only that the copper may be precipitated more rapidly, but in order to avoid the formation of a basic iron salt, which is very liable to contaminate the copper when it is precipitated in the cold. This basic salt frequently forms during the precipitation, even in warm solutions, if they are not sufficiently acidulated. If a solution be at the same time somewhat concentrated, and not sufficiently acid, it often happens that a portion of the copper becomes so firmly attached to the iron that it cannot be rubbed off. This accident will rarely occur, however, to any one accustomed to the assay.

It is remarkable that no one who has written upon this process has, so far as I can ascertain, appreciated the necessity of igniting the dry copper in a current

* Proceedings of Boston Society of Natural History, IV. 296.

of hydrogen before weighing it. That this operation is of the first importance is, however, well known to the analysts of this vicinity, who have long been accustomed to apply it in practice.* It is necessitated less, as it appears to me, by the oxide of copper formed during drying, — for the bright surfaces of the copper precipitated by this method remain untarnished when rapidly dried at temperatures even as high as 110° to 115°, — than by an impurity consisting of organic matter derived from the iron; either carbon, or perhaps some one of the offensive hydro-carbons which are generated during the action of acids upon iron, which may adhere to the spongy copper. At all events, if a portion of the precipitated copper which has been dried at 100° — or at any temperature lower than that at which oxidation occurs — be placed, as was suggested to me by Mr. Dickinson, in a bulb tube with narrow outlet, such as is used in testing for arsenic, and heated in the flame of a spirit-lamp, it will be found that a quantity of water collects in the narrow part of the tube, while the copper becomes lustrous and assumes the bright red color proper to it. At first sight it would appear as if this behavior was produced by the reaction of a portion of the spongy copper upon the oxide of copper with which it might be soiled, in which event a small quantity of suboxide of copper would be formed, the color of which could hardly mask, to any extent, that of the pure copper. But on examining the reaction more attentively I have found that carbonic acid as well as water can readily be detected in the atmosphere expelled from the tube in which the copper is heated; a distinct empyreumatic odor is at the same time perceptible. I have also several times observed traces of ammonia. This gas is always evolved in considerable quantity when the dirty copper is heated in an atmosphere of hydrogen; the aqueous vapor driven off in this case being strongly alkaline from its presence. Organic matter must therefore have been attached to the spongy copper, and the lustre which the latter acquired when heated may have been occasioned by the simple expulsion of the impurity, or in part by the reduction of oxide of copper by it.

That the phenomenon does not depend upon the presence of free carbon seems to be proved by the fact that portions from the exterior of a mass of spongy copper, which had been protected from contact with the iron by a layer of copper nearly an inch in thickness, were found to exhibit reactions similar to those just described, water and empyreuma being evolved when the dry copper was heated in a closed tube. Indeed,

* In lieu of this, some assayers convert the precipitated copper into oxide, and weigh the latter.

the formation of water in any case in Mr. Dickinson's experiment with the arsenic-tube is an insuperable objection to this explanation, as well as to the idea that mixed copper and oxide of copper have reacted upon each other.

I have determined the quantity of this impurity in some fifty or sixty instances: it was found to vary from 1.5 per cent or less to 4 or even 5 per cent, in exceptional cases, of the copper dried at 100°; ordinarily it was from 2 to 2.5 per cent. These remarks refer to copper precipitated from sulphuric acid solutions, which is usually in a porous spongy state. When precipitated from chlorhydric acid solutions, it is usually crystalline and compact, and doubtless contains less impurity. It is said, however, that a certain amount of loss will invariably occur, even when the best samples of copper precipitated by iron are heated in an atmosphere of hydrogen. Even in copper precipitated by pure zinc I have observed that an appreciable loss occurs, — varying in my experiments from 0.5 to 2 per cent of the dry copper, — when it is ignited in hydrogen gas. It would appear that, while copper may be determined with great accuracy when precipitated by pure zinc in a platinum vessel, as recommended by Fresenius,* even when the precipitate is dried only at 100°, for in this case the copper is deposited in a condition so compact that little or no impurity can adhere to or oxide form upon it, yet it can hardly be determined with nicety when precipitated in the spongy state, unless it be ignited in a current of hydrogen, or converted into oxide before weighing; it is necessary also to exercise the greatest care that none of the smaller particles of copper, are lost during the washing, for many samples of copper, when precipitated as sponge by zinc, are peculiarly liable to this accident.

In regard to the assay which I have attempted to describe, I would remark that I have used iron instead of zinc,† simply because I was, at the time, unable to procure a sufficient quantity of the latter in a state pure enough for analytical purposes. The assay by iron, as I have used it, is clearly not an accurate analytical process, but, on the other hand, it is in several respects preferable — as an assay — to the method by zinc, and will be found, after a little practice, to yield satisfactory results. It is doubtless as good a method as any which we possess, wherever absolute accuracy is not required, and where a large number of determinations must be made. Admitting that the results obtained by it may vary among themselves within the limits of one per cent, or in exceptional cases even to the extent of one

* *Anleitung zur Quantitative chemischen Analyse*, (Braunschweig, 1858,) S. 247.

† Method proposed by Vauquelin, *Annales de Chimie*, (1798,) XXVIII. 50.

and a half per cent, I have still deemed it sufficiently accurate for the work to which I have applied it; for it must be remembered that these differences are much smaller than the variations in composition which may occur in different parts of the same cup of alloy, from partial volatilization of the zinc, or from incomplete mixture of the metals of which it is composed.

I may also remark, that although this assay was not adopted by myself until after thorough trial of several other processes which seemed to be applicable to the special case with which I was occupied, I now consider it a very valuable method.

It deserves mention in this connection, that the assay by iron has been entirely misunderstood by some writers. Thus, Mitchell * directs that the whole of the iron added shall be dissolved in chlorhydric acid, just as if it were zinc, after the copper has been completely precipitated; the absurdity of which procedure is manifest.

In concluding the subject, I may observe that American assayers are accustomed in practice to use a mixture of nitric and chlorhydric acids as a solvent in the first instance of the sample to be assayed, and to expel the nitric acid by evaporating twice to dryness with an excess of chlorhydric acid. The copper being then precipitated from the hot chlorhydric solution. Some of them collect the copper upon a filter, instead of washing by decantation, and rinse it once or twice with very dilute chlorhydric acid before washing with water.

This process has the advantage, that a larger portion of the impurity of the iron is soluble in chlorhydric than in sulphuric acid, hence there is less chance of the copper being contaminated by it; basic iron salts are also less liable to form; the evaporations, which are conducted over the sand-bath, consume somewhat less time than when sulphuric acid is used; and the copper, being precipitated in a crystalline state, is easily washed without loss, and is not liable to be attacked by the acid solution.†

On the other hand, in the process by sulphuric acid, — which I have used merely in order to remove the lead which is contained in the alloys, — the last traces of copper seem to be somewhat more readily precipitated from the solution, and the accident of the copper adhering too closely to the iron occurs, perhaps, more rarely.

Of the special precautions which must be taken when this assay is applied to

* Manual of Pract. Assaying, (London, Baillière, 1854,) p. 257.

† The assay undoubtedly affords more accurate results with chlorhydric acid than when sulphuric acid is used. Mr. Dickinson assures me, that in his hands variations so great as 0.5 per cent are entirely exceptional, the usual difference between any two assays of a homogeneous sample of ore not being larger than 0.2 to 0.3 per cent.

the various impure ores of copper, I cannot here speak. Many of them have been already described by Kerl.* I would, however, mention the fact, that, in cases where arsenic is the only impurity, it has been found advantageous in practice to precipitate it upon iron with the copper, and to expel it subsequently when the latter is heated in the atmosphere of hydrogen.

It is a well-known fact, that the combination of copper with zinc is attended with ebullition of considerable violence, so that portions of the melted mass are often thrown to a distance of several feet from the crucible. Yet it does not appear to have been previously noticed by chemists, that this action is much more energetic while the first portions of zinc are being added to the copper, and that the loss of zinc by volatilization is far greater at this time than at any subsequent stage of the operation; indeed, when the alloy has become somewhat rich in zinc, it takes up an additional portion so quietly, that scarcely any action is to be observed. The fact is, however, well known to brass-founders, who are in the habit of first melting a quantity of old brass with the copper in their crucibles before adding any zinc as such.

A very violent action will also occur, if, after allowing the zinc to melt and remain floating above the copper, as it will do if the mass is not agitated after each addition of zinc, the two metals are suddenly stirred together. This action is apparently analogous to that observed by Levol,† which occurs when layers of melted silver and gold are mixed. Levol ascribes the violent ebullition which ensues when these metals are stirred together to the escape of oxygen which had been absorbed by the molten silver, and which would be expelled as soon as this metal unites with the gold. This hypothesis, however, does not in my opinion satisfactorily explain the phenomena which occur in the case of copper and zinc. Another explanation is afforded by the experiments of Person,‡ who has shown that in the formation of certain alloys a large amount of latent heat is evolved.

The apparent energy with which the combination of copper and zinc occurs, is often mentioned in treatises on chemistry, as if it indicated the existence of strong chemical affinity between the two metals. Yet it is easy to separate the zinc completely from any of these alloys by heat. Indeed, Bobierre § has devised a method

* *Op. cit.*, S. 219.

† Ann. Ch. et Phys., (3.) XXXIX. 168.

‡ Ibid., XXIV. 146.

§ Thèses, p. 57; also, Compt. Rend., XXXVI. 224.

for their quantitative analysis, by heating the sample of alloy in a porcelain tube, through which a current of hydrogen is made to flow.

In preparing the alloys, it may readily happen, if the mass be not very frequently stirred, that a small portion of the copper, or of an alloy rich in copper, may become chilled and solidify at the bottom of the crucible, while a quantity of easily fusible alloy, rich in zinc, has formed and remains liquid above it. Accidents of this nature happened to myself very frequently during the earlier part of the research. They occasioned no inconsiderable loss of time, since it was in every instance necessary to prepare a new sample of the alloy on account of the enormous waste of zinc which would occur if one attempted to remelt the chilled *culot;* and were especially vexatious, from seeming to indicate the existence of definite alloys having little or no affinity for each other. Similar accidents sometimes occur in brass-founderies, but are evidently less liable to take place here, where the amount of melted metal is large and the heat well regulated, than in the small crucibles and furnaces of the chemical laboratory. It is worthy of remark, that many brass-founders refer them to some peculiarity of the particular sample of copper used. If any trouble of this kind is experienced, a portion of common salt is usually thrown into the crucible, it being regarded as a remedy. It is very probable that the presence of some foreign metal may prevent or retard combination; on the other hand, copper which still contains a portion of sulphur is thought to combine with zinc with peculiar facility. In my own experiments these occurrences appeared to depend entirely upon irregular heating of the furnace, or upon insufficient stirring. D. Forbes * has analyzed such specimens which were produced accidentally in the ordinary process of brass-making. They consisted of a white alloy containing 46.51 per cent of copper, and of a yellow alloy containing 56.91 per cent of copper. From my own experience, I am satisfied that layers containing almost any proportion of the two metals may form.

It is doubtless this tendency of the metals to remain unmixed in separate layers, when not subjected to agitation, which has led several chemists to believe that the alloys of copper and zinc are apt to separate by eliquation into two portions respectively rich in copper and in zinc; from which they have inferred, as I have previously remarked, the existence of definite compounds. Although in my own experiments I have been unable to detect any eliquation, I would by no means

* Report of 24th (Liverpool) Meeting of the British Association for Advancement of Science, 1854, p. 67. See also Liebig and Kopp's *Jahresbericht.*

assert that a certain amount of such separation may not under some circumstances occur. The method of analysis which I have adopted is not delicate enough, nor will the very conditions of the case itself admit of an accurate determination of this point. My results are, however, as I think, sufficient to show that any tendency towards eliquation which may exist must be very slight, although they do not prove that a small amount of it may not be produced by gravity, or by some other force acting against the comparatively feeble affinity of the metals for each other. Experiments upon this subject which have been recorded by previous observers have evidently been exposed either to the error of insufficient mixing in the first instance, or to the loss of zinc by volatilization from those portions of the alloy which were in contact with the air, or to both of these causes. Some of them appear to have also been influenced by the presence of foreign metals in the alloy.

The most contradictory statements have been made by different observers in regard to variations of color among the alloys of copper and zinc. In the specimens which I have myself prepared, no abrupt change, or peculiar modification, of the true color is to be perceived, although some very striking superficial characters present themselves. Starting from the red of pure copper, the color of the alloys is less red and more yellow in proportion as they contain more zinc, until an alloy containing 75 or 80 per cent of copper is reached, the color of which is almost pure yellow; beyond this point, as the proportion of zinc contained in them is increased, the alloys become less yellow, with perhaps a tinge of green, and more white continually, and this by the most gradual stages, until the well-known white alloys are reached. These remarks refer to the color of polished surfaces, as obtained by the use of a fine file. Each of the alloys enumerated in the list upon page 42 having been carefully compared with the chromatic scales of Digeon.*

In several of the alloys, especially in those containing about equal parts of copper and zinc, a beautiful yellow or sometimes gray iridescent film forms upon the surface of the metal during the process of cooling. On fracturing it, moreover, the fibres of which the mass is formed present the same yellowish or grayish iridescence. This is removed at once by filing, when the true color of the alloy is made manifest, as has already been observed by Guettier† in regard to hard-solder. With the exception of Guettier, most modern observers have described this alloy, prepared by fusing

* Cercles Chromatiques de M. E. Chevreul, reproduits au Moyen de la Chromocalcographie, par R. H. Digeon, Paris, 1855. Chez Digeon, Rue Galande, No. 65.

† *Loc. cit.*, S. 207.

together 50 parts copper with 50 of zinc, as being of a deep yellow color; while Karsten* states that it is considerably darker and redder than ordinary brass.† They have evidently all been misled by the superficial coating just described, the color of which is completely analogous to that which occurs upon the crystals of metallic bismuth, now so often to be found in chemical cabinets; or by the color of an almost equally superficial layer of yellow alloy, which forms upon those parts of the ingot which are suddenly cooled. To these changes produced by "tempering" I shall presently again allude. That the surface color is most probably mainly due to oxidation, however, would appear from the fact that not only has the brilliant yellow coating of my specimens of braziers' solder, and of other iridescent alloys, not been dimmed by exposure during several months in a damp cellar, where ordinary polished brass soon became tarnished, but in several instances in which it had been removed by filing, a somewhat similar yellow coat has reappeared after exposure to moist air. Although this iridescence is very strongly marked in the alloy known as braziers' solder, yet an instance perhaps still more striking presented itself in the alloy containing 41.48 per cent of copper. Being very brittle, a specimen of this alloy was accidentally broken into several fragments before it had become thoroughly cold, when a beautiful, glittering iridescent film of a light yellow color at once formed upon its surface. As the alloy was very compact and fine-grained, it could at first sight hardly be believed that the coloration was only superficial; but on breaking the mass after it had become cold, its true color was found to be a very light gray, — indeed, almost white, — as was also proved by filing off a portion of the yellow film. The ingot obtained from the liquid portion of this alloy, having been suddenly cooled, was nearly white, and presented no appearance of iridescence. Upon its under surface, however, which had been instantly solidified by contact with the cold stone upon which it was poured, a thin layer of yellow, malleable, *tempered* alloy was found. In another instance, the ingot obtained from a white alloy containing about 30 per cent of copper having been broken while still warm, the fractured surface instantly assumed a permanent bright

* *Loc. cit.*, S. 394.

† When a piece of solder is heated gradually, it assumes at first a light red color, which subsequently passes to violet, or even to blue violet; a beautiful play of colors, alternating between green, yellow, and violet, succeeds, as the temperature becomes more elevated, until at length, after the lapse of some time, the specimen becomes tarnished with a thick, dull coating of oxide. Since in the founderies where it is prepared this alloy is often taken directly from the ingot-moulds and pounded to powder without having first been allowed to cool, the observation of Karsten admits of ready explanation.

blue-violet color. Indeed, it would appear as if, by properly regulating the process of cooling, a series of colors as varied as those assumed by steel, according to the different degrees of heat at which it is tempered, might be obtained. Alloys containing about 45 per cent of copper exhibit a dull gray coloration on fracture, which, combined with their other physical properties, often causes them, when unpolished, to resemble, as was remarked by Karsten,* metallic sulphides far more than metals.

Although the iridescence which I have described is perhaps seen to best advantage in the alloy from equal parts of copper and zinc, and may perhaps be produced most readily upon it and the neighboring alloys of a fibrous texture, it is by no means confined to these. I have noticed beautiful yellow coatings upon alloys containing 60, 53, and particularly on the one of 90.77 per cent of copper. It may probably occur upon any of the yellow alloys, and is doubtless produced at will upon some of them by manufacturers of ornamental brass castings.

In this connection, it may be mentioned that the color of the oxidized surface of the thin sheets of alloy obtained by pouring upon stone varies from a grayish black, tinged with blue, in the specimens containing about 90 per cent of copper, to a dirty dark yellowish-green, as in the alloy of 65 per cent of copper; and from a dull lead color (alloy of 38.5 per cent of copper) nearly to white, in the alloys rich in zinc.†

Marked changes, not only of color, but also in other of the physical properties of some of these alloys, may be produced by varying the conditions in which they pass from the liquid to the solid state. These changes are very peculiar, and are evidently of great importance, not only in their practical bearing, but also from affording another instance of the phenomena of "tempering," which may possibly be of consequence in the study of this most difficult subject.

In preparing the white alloys containing less than 45 per cent of zinc, I have

* *Loc. cit.*, S. 396.

† Observations upon the color of the alloys of copper and zinc which accord very nearly with my own are those of Guettier (Dingler's Polytech. J., CXIV. 204, (from the *Moniteur Industriel*, 1848), and of Lewis (Chemical Works of C. Naumann, Abridged and Methodized, with Additions, by W. Lewis, (London, 1759,) p. 65), who long ago wrote: "The proportion of Calamine and the increase which the Copper receives from it are different in different works: hence the deeper or paler colour of Brass. I have observed in a large set of experiments on this subject that a little of the Calamine, that is, of the Zinc contained in Calamine, dilutes the colour of the Copper and renders it pale; that when the Copper has imbibed about one twelfth its own weight, the colour inclines to yellow; that the yellowness increases more and more till the proportion comes almost to one half; that on further augmenting the Calamine, the Brass becomes paler and paler, and at last white."

frequently observed, upon the under surface of the sheet obtained by pouring off the liquid alloy, a thin layer of a soft, tenacious, malleable alloy, of a yellow color. The formation of this singular sheet was at first attributed to eliquation; but as it was difficult to conceive that an alloy apparently richer in copper should remain at the surface of the melted mass in the crucible, — which must have been the case in order that it should form the bottom of the ingot, — it was thought possible that volatilization of the zinc might have increased the proportion of copper at the surface of the melted alloy. In order to decide this question, a new series of alloys was prepared, extending from the one obtained by melting together 40 parts of copper plus 60 parts of zinc, to the mixture of 56 parts of copper and 44 parts of zinc; — each alloy being made from a mixture containing one per cent more copper than that used in preparing the preceding. After thorough stirring, the alloys were cast into ingots of about five pounds' weight. In the first four of these alloys — from 40 to 44 per cent of copper — the yellow film was very clearly defined on the three sides of the ingot which had come in contact with the metal of the mould, while on the upper surface of the ingot, which had cooled in contact with the air, no trace of it could be detected. This yellow film is usually of extreme tenuity, hardly exceeding one sixteenth of an inch in thickness in any of the instances which I have observed. It is, however, so very clearly defined in the white alloys containing 40 to 45 per cent of copper, being readily bent, cut, or filed, while the remainder of the alloy is exceedingly hard and brittle, that no question as to its identity can possibly be entertained. In the alloys containing more than 50 per cent of copper, which are naturally of a yellow color, it is not so easy to detect a similar film. In the series of ingots just mentioned, it could nevertheless be traced as far up as the alloy prepared from 54 parts of copper plus 46 parts of zinc.

An experiment made in order to ascertain whether this soft modification of the alloys could be obtained at will, afforded no positive result. An alloy of 42 parts of copper plus 58 parts of zinc being prepared, a portion of it was poured by small drops into a large mass of cold water. The surfaces of many of the granules thus obtained were covered with a yellow film, and this was especially true of the smallest pieces; but the film was exceedingly thin, and the interior of the granules consisted entirely of brittle white alloy. Other portions were thrown out upon cold iron plates, so as to form very thin sheets. A thin yellow film occurred, it is true, upon the inferior surfaces of these sheets, but above it the alloy was white and brittle. Another portion of the melted alloy was cast in an iron ingot-mould which had previously been heated "black-hot." The yellow film was still formed

where the alloy came in contact with the ingot-mould; it was, however, exceedingly thin. On pouring some of the remaining alloy into a cold iron mould, a yellow film of the usual thickness was obtained.

Although the phenomena of tempering exhibited by these alloys are more readily perceived among those the normal color of which is white, it is highly probable that all the alloys are liable to have their physical properties influenced to a greater or less extent from this cause. This would appear, not only from the evident analogy of these phenomena with those which are known to occur with alloys of copper and tin;* but Dussaussoy † has already shown that ordinary brass, copper 65 to 70 per cent plus zinc 30 to 35 per cent, is rendered softer, less tenacious, and less dense by tempering it; — a fact which Mallet ‡ has very properly urged in explanation of the differences between several of the specific gravities of alloys of copper and zinc observed by himself, and the numbers which had been previously obtained by other experimenters. I would here suggest that it explains equally well the very great variations among the specific gravities of the different alloys studied by Mallet himself.§ It is also the most probable explanation of the alloys of abnormal color which he has described. I should observe in this connection, that in the alloys of light yellow color the yellow appears to be made much deeper when the alloy is strongly compressed, as when cut with a cold-chisel or hammered. I may also incidentally mention, that in the series of alloys which I have prepared, a constantly increased degree of hardness has been observed, in proportion to the amount of zinc contained in the alloy, — at least as far as the brittle white alloys, which are so hard that an ordinary file makes little or no impression upon them; ‖ a result

* *Vid.* d'Arcet in *Dictionnaire de l'Industrie Manufacturière, etc.*, X. 500, Art. *Tam-tam* (Paris, Baillière, 1841); also, *Ann. Ch. et. Phys.*, (2.) LIV. 331. See also Dussaussoy, *Ann. Ch. et. Phys.*, (2.) V. 225.

† *Loc. cit.*, p. 226, *et Tableau* No. 5.

‡ *Loc. cit.*, p. 264.

§ I have found it impossible to construct a curve of any regularity from the observations of this chemist, although it is tolerably clear that the greatest condensation is at a point somewhere below the alloy composed of equal equivalents of copper and zinc, and that between this point and pure copper the specific gravity gradually increases with some degree of regularity in proportion as the amount of copper increases. Among the observed specific gravities of the white alloys rich in zinc, there is no regularity whatsoever. The determinations of Mallet are, nevertheless, unquestionably the best which have ever been made; possibly they are the best which could be made in any case. At all events, few chemists are in the position to improve upon the method of preparing alloys which was employed by this distinguished observer.

‖ From this category the alloys modified by tempering must of course be excepted.

which agrees with those of Karsten,* of Mallet,† and of Guettier.‡ Calvert and Johnson § have recently attempted to express these differences numerically. The alloy containing 54 per cent of copper, which is still so tenacious that small bits cannot readily be broken from it, was found to be exceedingly difficult to cut with a cold-chisel; for though still so soft that it could be filed without any very great trouble, it destroyed at once the edges of cutting instruments, though the latter were well tempered. This peculiarity appears to be connected with the fibrous structure of the alloy.

In conclusion, I must express my gratitude to my friend, Professor J. P. Cooke, of Cambridge, who has kindly invited me to make use of the admirable laboratory in which this research has been conducted. By his suggestion, moreover, my attention was first directed to the subject. Nor can I omit to mention the fact, that I am indebted to Messrs. J. Davis, Jr. and John Revere, officers of the Revere Copper Company of Boston, for the gratuitous use of the large quantities of metal which I have employed. I have also been permitted by them to make free use of the furnaces and other appliances in the extensive founderies of the company. For the valuable aid and uniform kindness of these gentlemen, I would here return my warmest thanks.

* *Loc. cit.*, S. 393. ‡ *Loc. cit., passim.* § *Loc. cit.*, p. 199.

† *Loc. cit.*, p. 307; also Gmelin's Handbook, (Cavendish Soc. Edit.,) V. 479.

Harvard College Laboratory,
September 1*st*, 1859.

III.

On the Impurities of Commercial Zinc, with special Reference to the Residue insoluble in Dilute Acids, to Sulphur, and to Arsenic.

By CHARLES W. ELIOT and FRANK H. STORER.

(*Communicated May* 29, 1860.)

When common zinc is dissolved in dilute acids, as in the ordinary process of preparing hydrogen, a finely divided black substance remains undissolved, sometimes floating, sometimes sinking in the liquid. . The blackness and apparent lightness of this residue from zinc dissolved in dilute acids seem to indicate that it is carbon, which may perhaps account for the widely spread error that carbon is the chief admixture in crude zinc, as it is in cast-iron. This error has been often corrected, but the information on the whole subject lacks precision and certainty. The statements of the best authorities in regard to the impurities of zinc are for the most part loose, inaccurate, and sometimes contradictory.* To obtain precise and definite knowledge, if possible, of the chief impurities of this important metal, this investigation was undertaken.

* The black residue was observed and experimented upon by Hellot (Mémoires de l'Academie des Sciences, 1735, [Mem.] p. 18, *et seq.*) and by De Lassone (Ibid. 1777, [Mem.] p. 11 *et seq.*)

Bergmann says, in his Physical and Chemical Essays, translated by Cullen, London, 1788, II. 321, that pure zinc is extremely rare, and commends the zinc brought by Grill from China as containing scarcely half of one per cent of lead; the zinc of Goslar is stated to contain somewhat more lead, but neither of these zincs contained the smallest particle of iron.

Fourcroy. For an express statement that this black powder is *plumbago*, see Fourcroy's Elements of Natural History and Chemistry, translated from the Paris edition of 1789, London, 1790, II. 289.

Proust. "It is commonly thought that the black powder, which separates from its (zinc's) solution in sulphuric acid, is charcoal or a carbide of zinc: it is nothing but arsenic, mixed with a little lead and copper, which the reducing power of the zinc precipitates in the metallic state." Savans Étrangers, [2.] I. 211 (Paris, published in 1806). "Iron is found in very large quantity in it (zinc), and sometimes manganese." Ibid. 212. It should be remarked, that the precipitate produced by sulphuretted hydrogen, and called arsenic

In order to make the results obtained as general as possible, we have examined authentic specimens of all the commercial zincs which we were able to procure. These are: —

by Proust, was most probably cadmium, — a metal not discovered till 1817. (See Gilbert's Annalen der Phys., 1819, LX. 193.) This consideration is important, as it may serve to explain the very loose statements about arsenic in zinc which have since prevailed.

Vauquelin, in reporting on this memoir of Proust, says: "It has been, and still is generally thought that the black powder . . . . . . consists of carbide of iron." Annales de Chimie, 1800, XXXV. 51.

See also a remark by Proust, similar to that above quoted, on the impurities of zinc, in Annales de Chimie, 1803, LI. 72.

Fourcroy. "In proportion as this solution (in sulphuric acid) takes place, we see a small quantity of very black powder in a state of extreme division floating in the liquid, which has long been mistaken by chemists, and which is nothing else than carburet of iron or plumbago, existing originally in the zinc." Système des Connaiss. Ch., V. 377. See also the English translation, London, 1804, V. 533.

Vogel. "The black residue (from the sulphuric acid solution of commercial zinc) consists of carbon, iron, and sulphate of lead. French zinc contains neither copper nor arsenic, but a small quantity of lead." Schweigger's Journal für Ch. u. Phys., 1814, XI. 418. This observer expressly contradicts the statements of Proust and Thomson [*vide infra*] in regard to copper and arsenic.

Berzelius and Dulong give the impurities of commercial zinc as follows: — lead, tin, copper, iron, cadmium, and sulphur. Ann. de Ch. et Phys., 1820, XV. 388.

Houton Labillardière says: "I have examined several times the residue which the zinc of commerce leaves when dissolved in weak sulphuric acid; I have always found that it was formed of tin and of traces of iron; I have never encountered lead, although it is possible that some sorts of zinc contain it." Thenard's Traité de Chimie, Paris, 1824, V. 307.

Thomson. "It (the zinc of commerce) is never quite free from carbon; . . . . . it contains, likewise, small quantities of several metals." First Principles of Chemistry, 1825, I. 52.

W. Henry. "The zinc of commerce is never pure, but contains charcoal, lead, and sulphur. . . . . . Even after careful distillation, zinc is still liable to contain a small quantity of charcoal." Elements of Experimental Chemistry, 11th edition, 1829, II. 16.

These statements of the impurities of zinc have been extensively copied. "The common zinc of commerce generally contains a portion of lead, copper, iron, traces of arsenic and manganese, and a little plumbago: these impurities chiefly remain in the form of a black powder when it is dissolved in dilute sulphuric acid." Brande's Manual of Chemistry, 3d edition, 1830, II. 42.

De la Rive and Planche. "Commercial zinc contains traces of tin, lead, and sometimes more than one per cent of iron; also, a considerable amount of cadmium." From the Bibliothèque Universelle, in Pogg. Ann., 1830, XIX. 234. See also Ann. de Ch. et Phys., XLIII. 437.

Schlindler has found in commercial zinc, iron, lead, arsenic, copper, nickel, cobalt, manganese, carbon, and a small amount of uranium. Berzelius's Jahres-Bericht, 1832, XI. 126. This determination of uranium has been doubted by all subsequent observers.

"The following impurities in commercial zinc occur: — lead, arsenic, iron, copper, cadmium, antimony, manganese, nickel, cobalt, sulphur, and carbon." Brandes, in reporting on the prize essays of Bonnet and others upon the oxide of zinc. Ann. der Pharm., 1834, IX. 184.

1. Silesian zinc.
2. Vieille Montagne (Belgian) zinc.
3. New Jersey (American) zinc.

WACKENRODER, in an excellent paper on the oxide of zinc, maintains that the principal impurities of *Silesian* zinc are lead, cadmium, and iron. He found no arsenic in his own experiments, but admits the possibility of its occurrence in small quantities. Traces of copper he believes to exist in this zinc, but neither cobalt, nickel, nor manganese, as had been intimated by Hermann (Gilbert's Ann. der Phys., LXVI. 284). He observed the development of sulphuretted hydrogen from zinc treated with dilute chlorhydric acid; but doubts the occurrence of carbon in zinc, except as minute, accidental splinters, thus contradicting Fourcroy. Ann. der Pharm., 1834, X. 53.

TURNER. "It (zinc) frequently contains traces of charcoal, sulphur, cadmium, arsenic, lead, and copper; and iron is always present." Elements of Chemistry, 5th edition, 1834, p. 543.

FARADAY. "Most zinc leaves, when dissolved in dilute sulphuric acid, more or less residue, which contains various metals in the metallic state, as copper, lead, tin, iron, cadmium, &c." Ann. der Pharm., 1836, XVII. 21.

WITTSTEIN says that the metals with which common zinc is contaminated are iron, cadmium, tin, and lead. Cited in Ann. der Pharm., 1836, XX. 179.

KANE. "The zinc of commerce is impure; it contains traces of carbon, iron, cadmium, and often arsenic." Elements of Chemistry, 1842, p. 602.

BARRUEL says that he analyzed a quantity of the residues from zincs dissolved in dilute acid, which had accumulated in the laboratory of the Sorbonne during some years, and found in this mass (of very questionable origin) 58.5 tin, 34.5 lead, 5.5 sulphur, besides traces of iron, manganese, &c., which he did not determine. Wishing to verify this result, he examined the residue from some other zinc, and inferred that it was chiefly tin; but his own statement of the process employed would not lead to this conclusion. Comptes Rendus, 1842, XIV. 724.

ERDMANN and MARCHAND cite this observation in their journal, and remark in a note that an examination of similar residues gave them lead and tin, with traces of iron, carbon, and cadmium. Journal für pr. Chem., 1842, XXVI. 384.

A. ERDMANN noticed the occurrence of lead in zinc, and the impossibility of completely separating the lead by redistillation, because of the partial volatilization of the lead. Annalen der Ch. u. Pharm., 1844, L. 437.

BERZELIUS. "It (the zinc of commerce) contains often iron, lead, arsenic, copper, and charcoal." Traité de Chemie, Paris, 1846, II. 604. "We are ignorant to what extent zinc combines with carbon, but the zinc found in commerce always contains some." Ibid., 616.

URE. "The ordinary zinc found in the market is never pure; but contains lead, cadmium, arsenic, copper, iron, and carbon, from some of which it may be freed in a great degree by distillation; but even after this process it retains a little lead, with all the arsenic and cadmium." Dictionary of Arts, &c., 4th edition, Boston, 1853, II. 994.

PELOUZE and FREMY. "The zinc of commerce is never pure. It contains about a hundredth of its weight of foreign bodies, which are chiefly lead and iron; carbon, copper, cadmium, and arsenic are sometimes found in it." Traité de Chimie Générale, 2e édit., 1854, III. 35.

W. A. MILLER. "Commercial zinc contains a small quantity of lead and iron, and of a peculiar carbonaceous matter." Elements of Chemistry, 1856, Part II. 847.

4. Pennsylvanian zinc (Pennsylvania and Lehigh Zinc Works, Bethlehem, Penn.).
5. Vieille Montagne zinc, such as is used at the United States Mint.
6. A zinc labelled "Zinc pur," Rousseau Frères, Paris.
7. A sheet zinc of unknown origin, obtained in Berlin (Prussia).
8. An English zinc, made near Wrexham, North Wales.
9. An English zinc, from the Mines Royal, Neath, Glamorganshire.
10. An English zinc, from the works of Dillwyn and Company, Swansea.
11. An English zinc, from the works of the Messrs. Vivian, Swansea.

Our specimens of the first three spelters were obtained in blocks or ingots from the Revere Copper Company of Boston, by the kindness of John Revere, Esq.; we received our specimens of the fourth zinc in ingots, through Professor Brush of New Haven, directly from the manufacturers; the fifth zinc was procured in Philadelphia, by our friend, Professor J. P. Cooke, from the purveyors to the United States Mint. The sixth specimen was bought as pure distilled zinc, in 1856, at Paris, of MM. Rousseau Frères, dealers in pure chemicals. The four samples of English zinc are authentic specimens, for which we are indebted to the kindness of the Hon. Edward Twisleton of London. The eighth specimen is a spelter made "from silicate of zinc" at Minera, near Wrexham in North Wales; Belgian retorts are used in its manufacture, but no other details of the process are known to us.

A qualitative examination of the residues left by these zincs when treated with dilute acids, showed that they chiefly consisted of *metallic lead.* It will appear in the sequel, that lead is the chief impurity of commercial zinc, and that the carbon, tin, copper, iron, arsenic, and other impurities found in it by previous observers, occur either in very minute quantities, or rarely, and doubtless accidentally.

Lead. — We have determined quantitatively the amount of lead in each of the zincs above specified by the following process: — A weighed amount of each zinc was dissolved in dilute sulphuric acid, saturated with sulphate of lead. This acid was prepared by diluting common sulphuric acid with four parts of water, and allowing the mixture to settle for some days before decantation. When the zinc was dissolved, the black residue was in each case separated from the solution by decantation, treated with a few drops of nitric acid, and gently evaporated to dryness. The white residue thus obtained was then washed with the same dilute acid into the original solution of the zinc, which was filtered after standing forty-eight hours, and the precipitated sulphate of lead was weighed on a tared filter. The results of these analyses are given in the following table: —

TABLE I.

(1.) Name of Zinc.	(2.) Weight of Zinc taken.	(3.) Weight of Pb O, S O_3.	(4.) Corresponding Weight of Lead.	(5.) Amount of Lead in per cent.
	grammes.	gramme.	gramme.	per cent.
Silesian . . .	23.8066	0.5082	0.3472	1.46
Vieille Montagne .	25.2795	0.108	0.0738	0.292
New Jersey . . .	28.672	0.033	0.0225	0.079
Pennsylvania . .	26.522	No residue.	0.0000	0.000
Mint	24.5308	0.1768	0.1212	0.494
Rousseau Frères .	24.3432	0.0379	0.0259	0.106
Berlin	23.074	0.4381	0.299	1.297
Wrexham . .	29.999	0.5235	0.3569	1.192
Mines Royal . .	38.8276	0.469	0.3197	0.823
Dillwyn & Co. . .	31.6425	0.771	0.5256	1.661
Messrs. Vivian . .	27.724	0.6165	0.4203	1.516

Two points in the process required examination. In the first place, it was unadvisable to use pure sulphuric acid, because sulphate of lead is not absolutely insoluble in dilute sulphuric acid; but the question suggested itself, whether by employing acid saturated with sulphate of lead, we might not introduce lead which would subsequently be weighed as sulphate. The following experiment answered this question. 0.2198 gram. of pure lead (*Probirblei* from the laboratory of Professor Plattner in Freiberg) was dissolved in pure dilute nitric acid, the solution evaporated to dryness, the residue so obtained dissolved in hot water, and precipitated as sulphate in 250 c. c. of our dilute sulphuric acid (one part of commercial acid and four parts of water.)

	gramme.
Weight of pure lead taken	0.2198
" " sulphate on a tared filter	0.3219
" " lead in 0.3219 gram. Pb O, S O_3	0.2199

After weighing the sulphate on a tared filter, we ignited the filter and precipitate, and, following the method of determining sulphate of lead which is prescribed in most text-books, again weighed the sulphate after ignition.

	gramme.
Weight of pure lead taken	0.2198
" " sulphate of lead after ignition	0.3123
" " lead in 0.3123 gram. Pb O, S O_3	0.2134

This result conclusively proved that none of the minute quantity of lead in the sulphuric acid was weighed as sulphate at the close of the analysis. Secondly, it was necessary to inquire whether the insolubility of the sulphate of lead was diminished by the presence of a large amount of sulphate of zinc. To determine this point, a weighed amount of acetate of lead was dissolved in water, and added to a solution of

25 gram. of pure sulphate of zinc in 100 c. c. of water acidulated with 5 gram. of pure sulphuric acid. The precipitated sulphate was first weighed on a tared filter, and afterwards ignited, and again weighed. The results of two experiments are given in the following table: —

TABLE II.

	(1.) Weight of $PbO\bar{A}$ taken.	(2.) Weight of PbO, SO_3 on Tared Filter.	(3.) Weight of PbO, SO_3 after Ignition.	(4.) Excess of PbO in Col. 2 over Calculated PbO in Col. 1.	(5.) Loss of PbO in Col. 3, from Calculated PbO in Col. 1.
	gramme.	gramme.	gramme.	gramme.	gramme.
No. 1.	1.1013 containing 0.6484 of PbO	0.8838 containing 0.6505 of PbO	0.8692 containing 0.6397 of PbO	0.0021	0.0087
No. 2.	1.0164 containing 0.5985 of PbO	0.8159 containing 0.6005 of PbO	0.8053 containing 0.5927 of PbO	0.002	0.0058

The filtrates from the sulphate of lead precipitates in these two experiments were saturated with sulphuretted hydrogen gas during forty hours, but not a trace of lead could be detected in either case. These experiments sufficiently prove that the accuracy of the determination of lead as sulphate is not impaired by the presence of sulphate of zinc, or, at least, that, if there be any error, it is an error on the safe side, causing a loss of lead, and not a gain.*

* The results given in Table II., and in the immediately preceding statement of the experiment with *Probirblei*, illustrate a fact which we have had frequent occasion to observe; viz. that the sulphate of lead can be weighed more accurately on a tared filter than by any process which subjects the filter and precipitate to ignition. There is an unavoidable loss in igniting this precipitate, in consequence of the volatilization of the sulphide of lead, which is reduced from the sulphate by the paper of the filter. The common objection to weighing this precipitate on a tared filter, is the difficulty of removing the last traces of the sulphuric acid used in washing; but careful washing with alcohol will overcome this difficulty, whereas no care can prevent the loss consequent upon ignition. We ignited 1.4004 gram. of absolutely pure sulphate of lead with a fine Swedish filter 10 centimetres in diameter, cut into small pieces, moistened, and mixed with the sulphate of lead. The sulphate, after ignition, weighed 1.3826 gram.

Amount of lead in 1.4004 gram. $PbO\ SO_3$		= 0.95654
Loss " by ignition		= 0.01216
" " "	in per cent	= 1.271

In this experiment the amount of sulphate of lead used was considerable; if this amount be small, the loss by ignition will be proportionally increased. It may be objected, that it is not usual to ignite the filter with the mass of the precipitate; but, on the other hand, it is often the case that the filter ashes cannot be burnt white on the crucible cover, and moreover the process of filtration produces a very intimate contact between the paper and the fine particles of sulphate of lead which is not imitated in the above experiment.

To verify the results stated in the third column of Table I., we determined the sulphuric acid in each precipitate of sulphate of lead, by the method described by Fresenius.* Each precipitate of sulphate of lead was digested with a solution of pure bicarbonate of soda prepared from the oxalate, and the sulphuric acid determined in the usual manner in the filtrate from the washed carbonate of lead. A comparison of columns 3 and 5 in Table III. made it at once clear that the precipitates of column 2 consisted only of sulphate of lead.

TABLE III.

(1.) Name of Zinc.	(2.) Weight of PbO, SO_3.	(3.) Sulphuric Acid in the Given Weight of PbO, SO_3.	(4.) Weight of BaO, SO_3.	(5.) Sulphuric Acid in the Found Weight of BaO, SO_3.
	gramme.	gramme.	gramme.	gramme.
Silesian . . .	0.5082	0.1341	0.3954	0.1359
Vieille Montagne .	0.108	0.0285	0.0845	0.029
New Jersey . . .	0.033	0.0087	0.035	0.012
Mint . . .	0.1768	0.0463	0.1356	0.0466
Rousseau Frères . .	0.0379	0.0100	0.0306	0.0105
Berlin . . .	0.4381	0.1156	0.3331	0.1146
Wrexham . . .	0.5235	0.1382	0.4282	0.1469
Mines Royal . . .	0.469	0.1238	0.3659	0.1255
Dillwyn & Co. . .	0.771	0.2035	0.5962	0.2045
Messrs. Vivian . .	0.6165	0.1627	0.4780	0.1640

Cadmium and Tin. — The filtrates from the precipitates of sulphate of lead obtained from the zincs in Table I., except the Pennsylvania zinc, were saturated with sulphuretted hydrogen for twenty-four hours or upwards, and the small precipitates which separated were filtered off, washed quickly with sulphuretted hydrogen water, dried, and ignited; they were then treated with a few drops of nitric acid, again evaporated to dryness, ignited, and weighed. The color of these precipitates was yellowish-brown, with the single exception of the precipitate obtained from New Jersey zinc, which was blackish. When this blackish precipitate from this zinc was moistened with nitric acid, the blue-green color of the partial solution suggested the presence of copper, and a separate determination of the amount of copper in this zinc was therefore made, and will be given hereafter. The color of the precipitates from the other zincs excluded all the metals of the group precipitated by sulphuretted hydrogen, except arsenic, antimony, tin, and cadmium. The first two of these metals do not exist in zinc, as we shall hereafter show, except in exceedingly minute quantities, and even any such minute quantity would probably have been driven off by the ignition, twice repeated, of the

* Anleitung zur Quantitativen Analyse, Braunschweig, Vierte Auflage, 1858, p. 286, § 132, II. b. β.

precipitates. The small precipitates weighed must therefore have consisted of the oxides of tin and cadmium. The results of these analyses are given in the following table. The numbers in the fourth column show what per cent each weight in column 3 is of the corresponding weight in column 2.

TABLE IV.

(1.) Name of Zinc.	(2.) Weight of Zinc taken.	(3.) Weight of the Precipitate by H S, ignited with NO_5.	(4.) In per cent of the Zinc taken, these precipitates equal.	(5.) Result of the Blowpipe test for Tin.
	grammes.	gramme.		
Silesian	23.8066	0.013	0.0546	No tin, or but very uncertain traces.
Vieille Montagne	25.2795	0.0071	0.0281	Distinct spangles, probably tin.
New Jersey	28.672	0.1285	0.4471	Abundant spangles of tin, which gave the reaction with Au_2Cl_3.
Mint	24.5308	0.0024	0.0098	No tin.
Rousseau Frères	24.3432	0.0099	0.0406	Faint traces of tin.
Berlin	23.074	0.0041	0.0178	Distinct spangles, probably tin.
Wrexham	29.999	0.0021	0.0070	No tin.
Mines Royal	38.8276	0.0016	0.0041	A very uncertain trace of tin.
Dillwyn & Co.	31.6425	0.0011	0.0035	Faint traces of tin.
Messrs. Vivian	27.724	0.0079	0.0285	Distinct spangles of tin, which gave the reaction with Au_2Cl_3.

If it be remembered that the weights given in the third column are not the weights of the metals themselves, but of their oxides, it will be apparent that tin and cadmium together form but a very insignificant impurity in commercial zinc. In none of the ten samples analyzed, except the New Jersey zinc, can the sum of the tin and cadmium amount to one twenty-fifth of one per cent. The precipitates whose weights are given in column 3 (except New Jersey, which alone gave indications of copper), having been moistened with nitric acid, were digested with distilled water, and then filtered. Through the filtrates sulphuretted hydrogen was passed, producing in each case a dirty-yellow cloudiness, which was too small in amount to be further examined. That portion of each precipitate which was insoluble in water, and therefore remained on the filter, was examined before the blowpipe by incinerating the filter and precipitate on charcoal, and fusing them with neutral oxalate of potassa in the reducing flame. The fused mass was ground up in an agate mortar, and examined for metallic spangles; when these were sufficient in amount, they were dissolved in chlorhydric acid, and the solution tested with terchloride of gold. The result for each zinc is stated in the fifth column of Table IV. For Silesian zinc, the Wrexham (English) zinc, and the zinc

used at the United States Mint, the results were negative. To confirm these results, 25 gram. of Silesian zinc and 20 gram. of Mint zinc were separately dissolved in dilute chlorhydric acid, and the residues separated from the solutions just before the zinc had completely disappeared, in order to collect in the residues all the tin which the zincs might contain. Each residue was then treated with strong chlorhydric acid; the chloride of lead formed was separated by decantation, and the solution tested with terchloride of gold. No trace of tin could be detected in either case.

The precipitate produced in the solution of New Jersey zinc by sulphuretted hydrogen weighed after ignition 0.1285 gram. (see Table IV.), and gave evidence of containing copper. To determine whether it also contained tin, the precipitate was treated with nitric acid, and the matter insoluble in nitric acid was collected, and found to weigh 0.0389 gram. When this insoluble residue was reduced on charcoal before the blowpipe, it yielded metallic globules, the acid solution of which gave the characteristic reaction for tin with terchloride of gold.

Copper. — No spelter except that from New Jersey gave the slightest evidence of the presence of copper. We determined the per cent of copper with which that zinc was contaminated by the following method: 17.9452 gram. of the zinc were dissolved in pure chlorhydric acid, and the residue, having been treated with nitric acid, was added to the original solution, through which sulphuretted hydrogen was then passed. The precipitated sulphide of copper was filtered off, washed with sulphuretted hydrogen water, dried, and separated from the filter. The filter was then burned, and its ashes, wet with sulphide of ammonium, were added to the previously separated sulphide of copper; the whole was then ignited in a current of hydrogen, and the resulting disulphide of copper weighed.

Weight of zinc taken . . .	17.9452	grammes.
" " disulphide of copper . .	0.0292	"
" " copper corresponding .	0.0233	"
Per cent of copper	0.1298	

In what way copper was introduced into this zinc, we do not undertake to explain.

We subsequently examined, in connection with our experiments on carbon in the residue from zinc dissolved in dilute acids, the precipitates produced by sulphuretted hydrogen in the chlorhydric-acid solutions of several different spelters. The experiments simply served to corroborate the results which have been already stated, as obtained with sulphuric-acid solutions of the different zincs, only one new fact being developed, the presence of a trace of cadmium in the Pennsylvanian zinc. From

previous experiments made by Prof. Brush we had learned that some specimens of this spelter contain noticeable quantities of Cadmium.

Iron — is usually to be found in commercial zinc, and enough quantitative determinations of the amount of this impurity have been already published to show that it very rarely exceeds in amount two tenths of one per cent, and that, moreover, it is an impurity introduced into the zinc from the iron moulds in which the spelter is generally cast. Karsten, in his admirable memoir on the "Admixtures which diminish the Tenacity of Zinc," has sufficiently proved that the zinc takes up iron from the moulds, by determining the iron in the zinc before and after the process of casting. It is true that Karsten experimented upon Silesian zinc alone, but the same contamination of the spelter would be produced in any works in which the process of casting in iron moulds was used.* We have made determinations of the iron in three samples of zinc volumetrically by permanganate of potassa,† but have thought it not worth while to multiply analyses upon a point already sufficiently clear.

1. New Jersey zinc gave	0.2088	per cent	of iron.
2. " " "	0.2087	"	"
3. Mint zinc "	0.0585	"	"
4. " " "	0.0566	"	"
5. Berlin zinc (sheet) "	0.0674	"	"
6. " " " "	0.0549	"	"

Besides the metallic impurities which have already been mentioned, it has been stated by previous observers, in places already cited, that nickel, cobalt, manganese, arsenic, and antimony are sometimes to be found in the zinc of commerce. The pres-

* Karsten determined the iron in three samples of "Werkzink," by which term he designates the zinc which is the immediate product of the distillation, — a mass of drops partially fused together; and again determined the iron in the same samples after they had been cast into cakes, and converted into the crude zinc (Rohzink) as it is found in commerce. His results may be tabulated as follows: —

	Iron in the Werkzink.	Iron in the Rohzink.
No. 1, ...	0.03 per cent.	0.154 per cent.
" 2, ...	0.04 " "	0.180 " "
" 3, ...	0.05 " "	0.210 " "

Karsten also shows that the refined zinc, obtained by remelting the crude zinc on the hearth of a reverberatory furnace, is almost absolutely free from iron. Archiv. f. Mineralogie, Karsten u. Dechen., 1842, XVI. 623. Also, Dingler's Polyt. Jour., 1842, LXXXVI. 193.

† For the description of the method, see Mohr's Lehrbuch der Titrirmethode, Zweite Abtheilung, p. 234. A sample of zinc from Stolberg gave Mohr 0.0442 per cent of iron, and a sample from Linz, on the Rhine, contained 0.126 per cent of iron.

ence of very small quantities of arsenic, and possibly of antimony, in many of the zincs of commerce is undeniable, but the amount of these metals present is so infinitesimal, that they can only be detected qualitatively by the most delicate tests, and a quantitative determination of either of them we regard as so nearly impossible as to be untrustworthy and incredible. A full discussion of the subject of arsenic as an impurity in commercial zinc will be found below. The occurrence of nickel, cobalt, and manganese in zinc has been denied just as often as it has been asserted, but it is of course impossible to assert the universal negative, that these metals are never to be found in any spelter, for zinc is an article of commerce which is manufactured in many different places, by various processes, from several different ores. Thus much may be safely asserted, that if nickel, cobalt, and manganese are ever to be found in commercial zinc, they occur there accidentally, exceptionally, abnormally, and in quantities hardly to be appreciated, and utterly insignificant.

But few quantitative determinations of the impurities of zinc are recorded, but we can confirm the results we have obtained with Silesian zinc by referring to the previous analyses of German zincs by several chemists. Thus Wackenroder,* in the memoir already cited, maintains that the principal impurities of Silesian zinc are lead, cadmium, and iron; and after him, Karsten draws the same conclusion from a considerable number of analyses of zincs from different works. In thirty-two analyses of Silesian zincs made by this eminent metallurgist, the amount of lead found varies from 0.24 per cent to 2.36 per cent.† A few other analyses we cite below.‡

* Ann. der Pharm., 1834, X. 53.

† Archiv. f. Mineralogie, Karsten u. Dechen, 1842, XVI. 597. Also in Dingler's Polyt. Jour., 1842, LXXXVI. 193.

‡ An East-Indian zinc, which Bonnet analyzed, contained, in 100 parts, 0.43 of lead, and 0.24 of iron. Ann. der Pharm., 1834, IX. 184. Jansen obtained a black residue weighing 2¼ ounces from 8 pounds of Silesian zinc. He states the result of an analysis of the residue as follows. (Ibid., 191.) The statement does not admit of any verification, is unintelligible and incredible.

Sulphate of Lead,	985.77
Oxide of Cadmium,	1.88
" " Copper,	1.56
" " Iron,	16.09
Carbide of Zinc,	4.03
Silicium,	13.77
Calcium,	2.26
Residue of Sand and Carbon,	13.00
	1038.36

Wittstein found in one sort of Austrian zinc as much as 3½ per cent of lead. Cited in Ann. der

Carbon. — With reference to carbon as an impurity of zinc, we have attempted to determine this single point, — Does it occur in the residue insoluble in dilute acids, as has been generally believed, but never to our knowledge proved? One fact alone renders the occurrence of carbon, or of any other non-metallic substance, in this residue extremely improbable. We have observed that the residues from the Silesian, New Jersey, Rousseau Frères, Berlin, and Mint zincs are completely dissolved in perchloride of iron, acidulated with chlorhydric acid. If carbon or silica were present in any appreciable quantity, complete solution of the residue in this reagent could not be expected. In testing the residues from our various spelters for carbon, we adopted the following process.

From thirty to forty grammes of the zinc to be tested were dissolved in pure dilute chlorhydric acid, the black residue thoroughly washed with hot water, and dried at a heat much below one hundred degrees. The dry, grayish powder was then ground up with fused chromate of lead, and the mixture was introduced into a small bulb, blown in a tube whose diameter was not quite a centimetre. At a short distance from the bulb, this tube was drawn down to a diameter of one or two millimetres, and the ex-

Pharm., 1836, XX. 179. Two other samples of Austrian zinc gave Wittstein, —

	(1.)	(2.)
Lead, ...	0.27 per cent.	0.91 per cent.
Cadmium, ...	0.23 " "	0.16 " "
Iron	trace.	0.17 " "

Otto's Lehrbuch der Anorganischen Chemie, Dritte Auflage, III. 139.

Jacquelain obtained from a specimen of French zinc, —

Carbon, ...	0.003
Iron, ...	0.142
Lead, ...	0.685

Ann. de Ch. et Phys., 1843, [3.] VII. 203.

The following additional analyses are cited from B. Kerl's Handbuch der metallurgischen Hüttenkunde, Freiberg, 1855, I. 225. The original sources from which these determinations were derived by Kerl are not stated.

	Lead.	Iron.	Cadmium.	Carbon.
1. Belgian zinc (2d quality) . .	0.4	0.4		
2. Silesian "	0.47	0.28	0.2 to 0.97	0.04
3. " "	0.15	0.32		0.75
4. Iserlohn "	0.30	0.35		
5. " "		0.25		0.41
6. Chinese " (bad quality) .	0.80	1.50		
7. Lower Hartz zinc, ...	0.85	0.73	(Also contains arsenic.)	

tremity of the fine tube placed under lime-water in a small test-glass. The bulb was heated till the chromate of lead was fused, and if any carbon had been present in the residue, the evolved gas would have caused a cloudiness or precipitation of carbonate of lime in the lime-water. In this manner we first tested our chromate of lead by itself, and found no cloud or precipitate in the lime-water. We next inserted the smallest possible particle of carbon into the bulb with a little chromate of lead, and obtained a large distinct cloud of carbonate of lime in the lime-water in the test-glass, and in the capillary tube which delivered the gas. Having thus proved the purity of the reagent employed, and the extreme delicacy of the test, we tested in succession the residues from Silesian, Vieille Montagne, and Berlin zincs, and from the zinc of Rousseau Frères. As precisely the same result was obtained with each of these zincs, it may be stated once for all.

On heating the mixture of residue and chromate of lead till the chromate fused, there appeared in each case a very slight deposit on the upper surface of the lime-water column in the fine tube. This deposit could not have been smaller and yet been visible; it was incomparably less than that produced by the atom of carbon which was purposely introduced into a similar tube, and was undoubtedly caused by the slight dust which collected on the residues during the processes of washing and drying, and which no possible precautions could entirely avoid. It is obvious from these experiments, that the often repeated statement, that the insoluble residue from zinc treated with dilute acids is carbon, rests on no adequate foundations, and that carbon is not an invariable constituent of crude zinc, as it is of iron. But on the other hand it is impossible to assert that carbon does not sometimes occur in commercial zinc as an accidental and wholly abnormal impurity. Thus in the specimen of New Jersey zinc which we examined, there were certain small cavities lined with black, as if a bubble of some carbonaceous gas had been decomposed within them, and the residue from this zinc, when tested as above described for carbon, produced a distinct cloudiness in the lime-water, which was sufficient evidence of the presence of a trace of carbon in this spelter; but the amount of this impurity was infinitesimal, and not at all to be compared in quantity with the lead and other metallic admixtures of which the residue mainly consisted. The presence of a little copper in this zinc may perhaps be connected with the occurrence of this trace of carbon. The residues from three of the English spelters also gave distinct reactions for carbonic acid in the lime-water; but, judging from the exceedingly small cloud of carbonate of lime produced, the amount of carbon in these zincs is even less considerable than that detected in the New Jersey zinc. The other English zinc (that from the works of Messrs. Vivian) yielded but the

merest trace of carbonate of lime, — a little larger deposit, perhaps, than that obtained from the Silesian, Vieille Montagne, and other zincs first experimented upon, but not more than may easily have been derived from the invisible dust which undoubtedly collected on the residue. From none of these zincs could we obtain nearly as much carbonate of lime in the test-glass as we got from the smallest possible atom of carbon heated with chromate of lead; and it is quite clear that there is never anything more than an infinitesimal amount of carbon in the considerable residue which remains when thirty or forty grammes of commercial zinc are dissolved in dilute acids.

Against the common opinion that carbon is one of the principal impurities of zinc, we would refer to the previously quoted statement of Wackenroder, who considered carbon only an accidental and mechanical impurity, and to the exact experiments of Karsten, who endeavored to determine the carbon in Silesian zinc by decomposing chloride of silver and chloride of copper by zinc, but "could find no trace of carbon in either the hard or the soft kinds of zinc." *

Sulphur. — It has been frequently stated that sulphur is a common impurity of zinc, and that it even occurs in the insoluble residue in combination with lead. We first tested the insoluble residue from Silesian zinc for sulphur, by dissolving about 30 grammes of the zinc in pure chlorhydric acid, separating the black residue, and dissolving it in pure nitric acid. It dissolved without any appreciable residue (another evidence of the non-existence of tin in this spelter), and the diluted solution gave no precipitate whatever with nitrate of baryta. With 40 grammes of Vieille Montagne zinc, we obtained precisely the same result. The Pennsylvanian zinc leaves no residue when treated with dilute acids, and is therefore free from lead, and certainly contains no carbon or sulphur which manifest themselves as an insoluble residue. The New Jersey zinc gave an exceptional result. The blackish residue, from 32 grammes of this zinc, could not be completely dissolved in boiling nitric acid. The partial solution gave no precipitate with nitrate of baryta; the undissolved portion was fused before the blowpipe with carbonate of soda free from sulphur, and gave a distinct reaction, first for sulphur, and secondly for tin. The presence of tin in this spelter has already been demonstrated, and a minute trace of sulphur must also be counted among its impurities.

In addition to this negative evidence, that no precipitation is produced by barium salts in the diluted nitric acid solution of the residues from the various zincs, we would

* Archiv. f. Mineralogie, Karsten u. Dechen, 1842, XVI. 607. Karsten also says: "I have cemented sheet zinc with coal for many days, and then melted it; but in the resulting mass of zinc I have found no trace of carbon." Ibid., 608.

adduce positive experiments to show that any compound of sulphur with a metal, which might be present in the zinc, would, in all probability, be decomposed in presence of an excess of zinc and free acid.

Wackenroder, in the memoir already cited, distinctly states that the black residue from zinc is sulphide of lead, — a statement at first sight sufficiently plausible, but really inconsistent with the facts of the case. When precipitated sulphide of lead is mixed with a large excess of granulated zinc (Silesian, Vieille Montagne, or Pennsylvanian), and treated with moderately dilute sulphuric or chlorhydric acid, the black sulphide soon entirely disappears, while torrents of sulphuretted hydrogen are evolved. If, after all the zinc has been completely dissolved, the insoluble residue is fused before the blowpipe with carbonate of soda free from sulphuric acid, the mass thus obtained will not blacken silver.

If powdered galena be substituted for precipitated sulphide of lead, the same effects will be produced, though much more slowly. The sulphide of lead, therefore, suffers complete decomposition in presence of an excess of zinc and free acid, and it is of course absolutely impossible that this substance should be found in the insoluble residue.*

The presence of sulphur in the insoluble residue from zinc is, without doubt, very rare; but it is also an unquestionable fact, that a certain amount of sulphuretted hydrogen gas is generated whenever commercial zinc is treated with dilute acids. This phenomenon has been often observed. Thus Blancard † remarks, "that the sulphur often contained in commercial zinc may be shown by bringing paper wet with acetate of lead in contact with the gas developed therefrom." Fordos and Gélis ‡ say, that "the formation of this gas (sulphuretted hydrogen) can only be attributed to the partial reduction of the sulphuric acid by the nascent hydrogen." Subsequently Jacquelain,§ doubting this supposed reduction of sulphuric acid, attributes the production of sulphuretted hydrogen to the presence of sulphurous acid or other compounds of sulphur,

* We have observed that the sulphides of tin and copper are also decomposed when mixed with an excess of zinc and dilute acid. The sulphide of copper was rapidly decomposed, and the residue, after all the zinc had been dissolved, yielded only a very uncertain trace of sulphur before the blowpipe. Precipitated bisulphide of tin was decomposed much less readily, and when all the zinc had disappeared, the residue gave indications of sulphur before the blowpipe. Although this might have arisen from some impurity in the tinfoil from which the sulphide was prepared, yet it was evident that the decomposition of the sulphide of tin is effected with much greater difficulty than that of the sulphides of lead and copper.

† Jour. de Pharmacie, 1841, p. 543, in Dingler's Polyt. Jour. 1841, LXXXII. 425.

‡ Comptes Rendus, 1841, XIII. 437.

§ Ann. de Ch. et Phys., 1843, [3.] VII. 189.

with which the sulphuric acid is contaminated. Every specimen of zinc in our possession develops sulphuretted hydrogen when treated with dilute sulphuric or chlorhydric acid, as may be manifested by placing a slip of paper moistened with alkaline acetate of lead in the neck of the flask which contains the zinc and acid. But the question recurs, What is the source of the sulphur which is necessary for the generation of this gas? Is it contained in the zinc, or is it derived from the acids used in the experiment? To obtain a satisfactory solution of this problem, it is necessary to use an acid which does not contain sulphur in any form. Sulphuric acid will not answer the purposes we have in view in this experiment; for though it is undoubtedly possible to prepare sulphuric acid free from sulphurous acid, yet the doubt would still remain concerning the reduction of the sulphuric acid by the hydrogen, — a reduction not impossible at certain temperatures and in certain states of concentration. In testing for a minute trace of sulphur in zinc, it is evidently undesirable to employ a reagent which contains sulphur, in however stable a combination. Sulphuric acid being then excluded, will chlorhydric acid answer the purpose? It is easy to prepare chlorhydric acid which gives no precipitate with baryta salts, but it is very difficult to prepare this acid from common salt and sulphuric acid, so that, while containing no chlorine, it shall be absolutely free from sulphurous acid, or some lower compounds of sulphur. Loewenthal's* test with sesquichloride of iron and ferricyanide of potassium will reveal the presence of such compounds of sulphur in chlorhydric acid, made with the utmost care, and in other respects pure. By means of chlorine or some similar oxidizing agent, these compounds of sulphur may undoubtedly be oxidized, or at least the larger part of these admixtures may be converted into sulphuric acid; whether their last traces can be oxidized in this way is a point by no means beyond a doubt. But if the chlorhydric acid has been treated with chlorine to accomplish this oxidation, it becomes necessary to remove from the acid the excess of the oxidizing agent, for sulphuretted hydrogen would not be developed from zinc, contaminated with sulphur, by an acid which contained free chlorine, or any substance of like properties. Thus common chlorhydric acid very often contains free chlorine, and no zinc will yield with such acid anything more than a very uncertain reaction for sulphur on lead-paper. To obtain chlorhydric acid which was above suspicion, and unquestionably free from every trace of sulphur, and from every oxidizing agent which might interfere with our reaction for sulphur in zinc, we found so difficult a task, that we finally rejected this acid altogether, and resorted to the following process. A solution of chloride of calcium, free from every trace of sulphur, was

* Jour. pr. Chem., LX. 267.

first prepared by dissolving carbonate of lime in chlorhydric acid, adding ammonia in excess to the boiling solution, filtering off the precipitated oxides of iron and alumina, adding to the filtrate chloride of barium, and evaporating to dryness. The residue was dissolved in distilled water, and in this solution a slight excess of chloride of barium was present, as was proved by the precipitate produced by a solution of sulphate of lime. Oxalic acid free from sulphur was then prepared by the following process: a quantity of commercial oxalic acid was treated with enough cold water to dissolve about half of the acid taken, and the cold solution thus obtained was partially evaporated and crystallized; the mass of crystals was washed with a saturated solution of a portion of the crystals, and was finally dissolved in distilled water. In these two reagents, the chloride of calcium and the oxalic acid, so prepared, no sulphur could be detected, either by barium salts, Loewenthal's test, or by the blowpipe reaction on silver.

We applied to every zinc in our possession the following test for sulphur. 10 or 15 grammes of zinc were introduced into a small flask, and a portion of the solution of chloride of calcium and of oxalic acid added thereto; hydrogen gas was freely developed, and was tested for any sulphuretted hydrogen which it might contain, by placing a slip of paper moistened with alkaline acetate of lead in the narrow neck of the flask. In every case the paper was immediately and strongly blackened, showing conclusively that every one of the following zincs contains sulphur in a quantity extremely minute, but distinctly appreciable if a sufficiently delicate test be applied:—

1. Vieille Montagne zinc (in two distinct samples).
2. Silesian zinc.
3. The United States Mint zinc.
4. Pennsylvanian zinc.
5. Rousseau Frères zinc.
6. Berlin sheet zinc.
7. Silesian zinc (subjected to Meillet's* process for purification from arsenic).
8. New Jersey zinc.
9. " " (reduced by us from the New Jersey white zinc oxide).
10. English zinc (in four distinct samples).

These results are not in accordance with the statements of some previous observers. Thus Karsten, in the memoir previously cited, infers that sulphur is not contained in Silesian zinc, from the fact that he obtained no precipitate in passing the gas gen-

* Dingler's Polyt. Jour., 1842, LXXXIII. 205, from Jour. de Pharmacie, 1841, 625.

erated by this zinc through a solution of acetate of lead. But it must be remembered, first, that we have no evidence that Karsten's acids were free from oxidizing agents, and secondly, that the reaction for sulphur on lead-paper is a more delicate test than any process of causing the gas generated to bubble through a liquid, even though the best form of apparatus be employed to secure as far as possible thorough contact of the gas with the fluid. Moreover, Karsten subsequently mentions that a delicate black precipitate is produced when the hydrogen from zinc is passed through nitrate of silver; this precipitate was probably sulphide of silver, and not metallic silver, as Karsten conjectured.

Again, Jacquelain, in the memoir already referred to, concludes that sulphur was not contained in the specimen of French zinc which he examined, because a complete solution of the zinc in aqua regia gives no precipitate with chloride of barium. But obviously the precipitation of sulphate of baryta in aqua regia is by no means a sufficiently delicate test for an amount of sulphur at best exceedingly minute. In the same paper, Jacquelain, criticising the observation reported by Fordos and Gélis of the generation of sulphuretted hydrogen from zinc and dilute sulphuric acid, implies that there is no sulphur in zinc by stating that the development of sulphuretted hydrogen from zinc may be avoided by using properly prepared acid. The acid which Jacquelain used had been saturated with chlorine gas, in a process of which the principal object was the purification of the sulphuric acid from sulphurous acid. That this acid occasioned no development of sulphuretted hydrogen from the zinc is not to be wondered at, but it is not to be argued from this fact, that there is no sulphur in zinc. With regard to sulphur in the zinc from New Jersey, Alger * has remarked that the New Jersey zinc ore is known to contain no sulphur; but, on the other hand, Jackson † observed the sulphuret of zinc in the mine of red oxide of zinc in Franklin, Sussex County, New Jersey, and a simple experiment demonstrated to us the existence of sulphur in that ore. 10 or 15 grammes of the red oxide of zinc, not entirely free from the gangue of carbonate of lime in which the ore occurs, were reduced to a fine powder, and treated with moderately dilute pure sulphuric acid. A vigorous evolution of sulphuretted hydrogen was the immediate result.

Arsenic.— The general opinion that arsenic is a very common impurity in commercial zinc may, we think, be traced back to the confident assertion of Proust, near the beginning of this century, afterwards extensively copied and generally believed. But it is quite clear that Proust, and probably many other of the early chemists, were led

* Am. J. Sci., XLVIII. 253.

† Proc. Am. Association, 1850, IV. 336.

into error by the close external resemblance of the sulphide of arsenic to the sulphide of cadmium, which last metal, not recognized till 1817, has since been shown to be a very common admixture in the zinc of commerce. The invention of Marsh's apparatus, in 1835, gave to chemistry a test for arsenic of most wonderful delicacy; and Marsh * himself, in his original memoir, describing his process, remarks, that "the only ambiguity that can possibly arise in the mode of operating above described, arises from the circumstance that some samples of the zinc of commerce themselves contain arsenic." But Marsh, thus careful to suspect his zinc, says not a word about the purity of his acid, and many observers since Marsh have been more ready to attribute the infinitesimal trace of arsenic, which his process has enabled them to detect, to the zinc, than to the acids they have used. Schauefele † has actually attempted to determine quantitatively the per cent of arsenic present in French, Silesian, and Vieille Montagne zincs, and his results have been quoted in many recent handbooks and treatises on toxicology.

The conclusions at which we have arrived, after a long course of experiments with many different zincs, and various acids, are these: — first, that much of the zinc of commerce is free from arsenic, or at least contains no arsenic that can be detected by the most delicate tests known for that metal; secondly, that the sulphuric and chlorhydric acids found in commerce do very often contain arsenic, and are always so liable to contain it as to be utterly unfit for use in Marsh's process without special purification for that purpose. The steps by which we were led to these results, and the evidence on which they are founded, we proceed to describe. We have used exclusively Marsh's process for the detection of arsenic, applied with the apparatus and with all the precautions recommended by Otto.‡ Our apparatus consisted of a flask provided with a funnel-tube, and a tube bent at right angles, with which were connected by connectors of sheet India-rubber, first, a tube of the form of a chloride of calcium tube, filled with asbestos; secondly, a similar tube, filled with pumice-stone soaked in caustic potassa; and thirdly, one filled with chloride of calcium. Through these three tubes, in the order in which they are named, the gas generated in the flask was obliged to pass before it arrived at the reduction-tube, which was of hard German glass, and about one centimetre in diameter. The reduction-tube was drawn

* Edinburgh New Phil. Jour., XXXV. 235.

† Extract from a thesis presented by M. Schauefele. Jour. de Chimie Médicale, [3.] VI. 173; also in Dingler's Polyt. Jour., 1850, CXVI. 248.

‡ A Manual of the Detection of Poisons. Translated from the German by Elderhorst. New York: Baillière. 1857.

down to a fine bore, and during the progress of an experiment was heated by one of Bunsen's triple gas-burners. To prevent any elevation of the temperature in the flask during an experiment, it was immersed in cold water, and the dilute acid used was always cold, and added in small quantities. With this apparatus (which for convenience we shall designate as Otto's apparatus), taking every possible precaution to insure its perfect cleanness, we made several experiments upon Silesian zinc. 200 grammes of this spelter, carefully granulated, were used in each experiment, and the sulphuric acid employed was a commercial acid made in this country from Sicily sulphur. We were not unaware of the fact, that arsenic is almost invariably found in the foreign sulphuric acid made from various impure sulphurs of unknown origin, or from pyrites;* but it is a common impression that the American acid manufactured directly from Sicily sulphur is free from arsenic. Positive statements to this effect have been made by chemists who have had mainly in view the common use of sulphuric acid in the preparation of chemical compounds used in pharmacy, and the assertion has enough plausibility to command ready and general belief. Using such acid and 200 grammes of granulated Silesian zinc, we obtained, at the end of the hour during which the reduction-tube was heated, a deposit of arsenic perfectly distinct, though not bright enough to be called a mirror. Our next experiment was made with the same acid upon 200 grammes of an excellent sample of Vieille Montagne zinc, perfectly clean and carefully granulated. At the end of the hour during which the gas was passed through the reduction-tube, a brownish, volatile coating was found in that part of the tube where the bore was smallest. These experiments on Silesian and Vieille Montagne zincs were several times repeated, and always with the same result; the deposit in the reduction-tube was often too thin and slight to be positively identified as arsenic, but it could not be distinguished from the deposit of that metal, and would have been perfectly fatal in a medico-legal investigation, or in any case in which absolute purity of

* On the subject of arsenic in foreign sulphuric acid, the following authorities may be referred to: —
Martius, Schweigger's Jour. f. Ch. u. Phys., 1811, III. 363.
Wackenroder, Ann. der Pharm., 1834, XII. 189.
Wackenroder, Ann. der Pharm., 1835, XIII. 241.
Vogel, Jour. f. pr. Ch., 1835, IV. 239.
Ficinus, Ann. der Pharm., 1835, XV. 77.
Berzelius, in his Jahres-Bericht, 1841, XX. 192.
Brett, Philosophical Mag., 1842, [3.] XX. 404.
Schnedermann and Wöhler, Jour. f. pr. Ch., 1845, XXXV. 186.
Dupasquier, Comptes Rendus, 1845, XX. 794.
Cameron, Chem. Gazette, No. 320, p. 75, in Jour. f. pr. Ch., 1856, LXVIII. 64.

the materials was desired. Not convinced that the zincs were the source of the arsenic, we desired to prepare a quantity of sulphuric acid in which the presence of arsenic could not possibly be suspected. To attain this object, we subjected a specimen of American sulphuric acid to the following process. The acid was first boiled with a little flowers of sulphur, as proposed by Barruel,* in order to free it from the nitrous fumes which the common sulphuric acid almost always contains; a small quantity of pure chlorhydric acid was then stirred into the cooled acid, which had been carefully decanted from the free sulphur, and the whole again boiled; to the acid, again cooled, a second addition of chlorhydric acid was made, and again the acid was heated till dense white fumes had been escaping for upwards of half an hour. During this process, the volatile chloride of arsenic is completely driven off, the second addition of chlorhydric acid being made, as has been recommended by H. Rose,† in order to insure this result. Lastly, a portion of chlorine-water was added to the cooled acid to oxidize any sulphurous acid which might be contained in it, and after a third boiling, the acid, cooled and diluted with three parts of water, was ready for use. This method of purifying sulphuric acid is a combination and modification of several well-known processes. Buchner ‡ has described in full the process of purifying sulphuric acid by means of chlorhydric acid, and the use of chlorine as above described was recommended by Jacquelain.§ The whole operation can be performed in a shallow evaporating-dish, and presents no serious difficulties of any kind. With the acid thus prepared, we tested 200 grammes of Vieille Montagne zinc, and after passing during more than an hour a continuous, gentle stream of gas through the reduction-tube, of which about four centimetres were maintained at a bright red heat, we found that there was absolutely no deposit whatever in the cool and narrow part of the reduction-tube. With the same acid and apparatus, 200 grammes of Pennsylvanian zinc (which had been proved to be altogether the purest zinc in our possession) gave absolutely no deposit of any kind in the fine reduction-tube at the end of one hour, the time during which, in all our examinations for arsenic, we maintained a steady flow of hydrogen through the red-hot reduction-tube. We had now demonstrated that two different spelters, of which we were fortunate in possessing considerable quantities, were free from arsenic, or, more strictly, that in the given quantities of metal, and in the stated times, Marsh's infinitely delicate test could not detect arsenic in these two zincs. It was also rendered

* Dingler's Polyt. Jour., 1837, LXIV. 55; from Jour. de Ch. Médicale, 1836, No. 4.

† Pogg. Ann., 1858, CV. 571.

‡ Ann. der Ch. u. Pharm., 1855, XCIV. 241.

§ Ann. de Ch. et Phys., 1843, [3.] VII. 191.

very probable that the sulphuric acid with which we first experimented contained arsenic, inasmuch as we had obtained a distinct deposit of arsenic from that acid and the Vieille Montagne zinc, which subsequent experiment had proved to be free from that impurity. In order satisfactorily to establish these conclusions, it was necessary to prove by frequent repetition that the same result might always be expected from these two zincs, and that their freedom from arsenic was a property shared by the whole sample, and not an accidental peculiarity of a particular fragment. At sundry times we therefore repeated again and again the long and careful test for arsenic above described with these two samples of spelter, and invariably arrived at the same conclusion; namely, that no deposit of any kind could be obtained in the reduction-tube from these zincs and purified sulphuric acid.

Delicacy of the Test. — To prove the sufficiency of our apparatus, and the absence of every substance which might be supposed to prevent the formation of the arsenic mirror, and, moreover, to obtain mirrors from known quantities of arsenic with which roughly to compare deposits obtained in experiments in which the arsenic was the unknown quantity, we made the following experiments: —

1. 200 grammes of Vieille Montagne zinc, about 200 c. c. of purified dilute sulphuric acid, and 20 drops of pure chlorhydric acid, were first thoroughly tested for arsenic, and found to be perfectly pure.

2. 200 grammes of Vieille Montagne zinc, and about 200 c. c. of purified sulphuric acid, were thoroughly tested, and gave no deposit in the reduction-tube. Into the flask whose contents had been thus proved, two tenths of a milligramme of arsenious acid (weighed on a Plattner's assay balance, made by Lingke of Freiberg), dissolved in 20 drops of the same chlorhydric acid used in the first experiment, were introduced. An enormous mirror of arsenic appeared instantly in the reduction-tube. To get the greatest effect, the arsenious acid should be thoroughly dissolved, and its solution should be effected without the use of any but a very gentle heat.

3. Using the same zinc and the same acids, in the same quantities which were employed in the foregoing experiments, and proving the materials as in the last experiment, we obtained, in half an hour, a very large and distinct mirror of arsenic, by introducing into the flask one tenth of a milligramme of arsenious acid.

4. 200 grammes of Pennsylvanian zinc and about 200 c. c. of purified sulphuric acids were tested for one hour, and proved to be perfectly pure. One milligramme of arsenious acid had been dissolved in 20 drops of the pure chlorhydric acid which had been used in the first experiment, and the solution diluted with distilled water to the bulk of 50 c. c. One cubic centimetre of this solution was introduced into the flask whose

previous contents had been proved as above described, and at the end of three quarters of an hour a distinct deposit of arsenic was found in the reduction-tube. The amount of arsenious acid actually placed in the flask was two hundred-thousandths of a gramme (.00002 gram.).

0.00002 gram. arsenious acid = 0.000015 gram. arsenic.

Ratio of the arsenic present to the zinc = 0.000015 : 200 = $\frac{75}{1,000,000,000}$.

" " " " " amount of liquid in the flask = about $\frac{75}{1,000,000,000}$.

Our apparatus was therefore competent to detect a quantity of arsenic less than one ten-millionth of the weight of the zinc used, or of the amount of fluid in the flask. This quantity of liquid necessarily varied somewhat, in consequence of the slight additions of acid necessary to maintain a constant current of hydrogen, but only varied to be increased, never diminished. Remembering the wide limits of error in many chemical processes, the comparative coarseness of most chemical tests, and the many unavoidable inaccuracies in weighing and measuring, is not the assertion perfectly safe, and in strict conformity with the general use of language in other qualitative or quantitative determinations, that a specimen of zinc is free from arsenic, which does not show the slightest trace of that metal in an apparatus abundantly capable of detecting the ten-millionth part of arsenic? We are aware that this is not the limit of delicacy * of Marsh's test, but, assured of this delicacy, we rest satisfied with it as sufficient for our present purpose. The more delicate the test, the stronger is our present argument, and the greater need is there of exceeding caution in applying this test in the investigations of medico-legal or pharmaceutical chemistry.

In connection with these experiments on the delicacy of the test, we would call attention to the fact, that the sulphuretted hydrogen, which we have shown in our examinations for sulphur to be always developed from commercial zinc, does not prevent the exhibition of such a very small amount of arsenic as 0.000015 gram. Chevallier,† and more recently Blondlot ‡ and Leroy,§ assert that the presence of the insoluble sulphide of arsenic cannot be recognized by Marsh's test, and that arsenic may therefore be concealed by being converted into the sulphide. This is the natural and general

* M. Signoret (Taylor on Poisons, 2d Edition, 1859, London, p. 396) states that he has procured metallic deposits with only the 200,000,000th part of arsenic in the liquid; but it is not clear from such a statement what the exact amount of arsenic in the apparatus was which enabled him to obtain deposits, — a very material point.

† Jour. de Ch. Méd., [2.] V. 380, in Berzelius's Jahres-Bericht, 1841, XX. 192.

‡ Comptes Rendus, 1857, XLIV. 1222.

§ Ibid., 1859, XLIX. 469.

opinion, though Marsh, in his original memoir, distinctly says, that "the presence of arsenic in artificial orpiment and realgar, ... and in sulphuret of antimony, may be readily shown by this process, when not more than half a grain of any of those compounds is employed." * When the amounts of arsenic and of sulphuretted hydrogen are alike minute, it is quite certain that the reaction for arsenic is not affected by the unavoidable presence of this gas.

Arsenic in American acids. — We have tested four different kinds of American sulphuric acid, of which two were commercial oil of vitriol, and two were sold as chemically pure acids. The test applied to these acids was always the same, and may be described once for all. 100 grammes of Pennsylvanian zinc, from the same bar which in many trials had been shown to be free from arsenic, was placed in the flask, and the acid to be tested was used instead of the purified acid which was always employed when the zinc was the suspected substance. In every experiment, the gas was passed through the reduction-tube at least one hour. In experiments several times repeated, the sulphuric acid made at Providence, Rhode Island, invariably yielded a distinct deposit in the narrow part of the tube. It should be stated, however, that the Providence acid used in these repeated experiments all came from one carboy. In a sample of the acid manufactured at Waltham, Massachusetts, we detected a similar trace of arsenic. The deposits obtained from these two acids were hardly larger than that produced by the 0.000015 gram. of arsenic used in the fourth experiment on the delicacy of the reaction, but, on the other hand, only a small quantity (from 25 to 50 c. c.) of the acid could be employed in a single experiment.

The arsenic which is eliminated from these acids during the process of purification with chlorhydric acid may easily be collected, and exhibited by Marsh's test. For this purpose, the sulphuric acid should be heated with the chlorhydric acid in a flask or retort, from which the gas generated is conducted into a small quantity of distilled water, kept constantly cool. The volatile chloride of arsenic condenses in the water, and the arsenic in the solution is readily manifested in Otto's apparatus. The chlorhydric acid used in this experiment must be absolutely free from arsenic; such acid may be obtained by passing sulphuretted hydrogen through chlorhydric acid prepared from salt and pure sulphuric acid. Moreover, the sulphuric acid in the flask or retort must be kept fuming during at least half an hour, in order to secure the complete volatilization of the chloride of arsenic.

The chemically pure sulphuric acid, so called, manufactured by Rosengarten, of

* Edinburgh New Phil. Jour., XXXV. 235.

Philadelphia, was purer than the commercial acid with reference to arsenic as well as to lead; indeed, in one experiment it yielded no sensible deposit in the reduction-tube, but in several subsequent experiments with pure zinc, in which we attempted to use Rosengarten's acid instead of that purified by ourselves, we obtained faint deposits which precluded its use, and showed it to be untrustworthy in such delicate examinations for arsenic by Marsh's process. To the "chemically pure" sulphuric acid made by Powers and Weightman of Philadelphia, precisely the same remarks apply; it is unfit for use in any research where scrupulous accuracy is necessary, and of which the results are worse than worthless if they be not certain and impregnable. It may be granted that the amount of arsenic in any small quantity of these acids is really too minute to be of any consequence, except in the most refined experiments. On the other hand, it must be remembered that in some pharmaceutical processes, and in many chemico-legal examinations for arsenic, in which a large amount of acid is often necessarily used, the whole of the arsenic contained in the reagents employed is, by the very nature of the process, concentrated and condensed into a very small compass. For example, in a poisoning case in which the chemist is obliged to destroy by acids any considerable portion of the body, as is often the case, it may be necessary to use many pounds of sulphuric or chlorhydric acid, and the very care and pains with which the chemist labors to concentrate every grain of arsenic in that organic matter into the small glass of liquid, which he finally tests by Marsh's process, also concentrates into the same glass all the arsenic contained in all the reagents which he has employed in the whole process. Under such circumstances the existence of *any* arsenic in sulphuric acid, capable of exhibition from a few cubic centimetres of the acid, becomes a fact of the utmost moment. From neglecting this arsenic in sulphuric acid arose the long controversy concerning normal arsenic in the animal body. To the objection that Marsh's test is too delicate, and that we should find all the elements everywhere if we had for each of them a test as refined as Marsh's for arsenic, it may be replied, first, that Marsh's process is not thought too delicate to base vital conclusions upon in difficult examinations for arsenic in poisoning cases, and secondly, that facts are not to be met by a theoretical objection, which is at any rate purely speculative, and furthermore is no objection if, as is certainly possible, the theory be true.

We are aware of the common opinion, that sulphuric acid made from Sicily sulphur contains no arsenic,* and we do not propose to explain the source of the arsenic found

* For a strong statement of this opinion, see Ure's Dictionary of Arts, &c., 4th edition, Boston, 1853, Vol. II. pp. 791, 799.

in American sulphuric acid, further than to suggest that its presence seems not unnatural when we remember that the sulphides of arsenic are often associated mineralogically with the sulphur from which the acid is made. Long ago Pfaff,* in commenting upon the observation made by Martius of arsenic in sulphuric acid, said that the sample analyzed by Martius was probably made from sulphur containing orpiment or realgar, minerals which are found with sulphur in the solfataras. Stromeyer † detected arsenic in the mixture of sal-ammoniac and sulphur, which is one of the many volcanic products of the Lipari Islands, and there seems to be no good reason for supposing that the sulphur, which is exported from the same locality, would escape contamination with arsenic. Daubrée ‡ has remarked that arsenic, as sulphide, occurs in the fissures of the lavas at Etna, at Vesuvius, and at the solfataras of Pouzzoles and of Guadeloupe. Scacchi § also states, that among the subtances found in the fumaroles of the solfataras are pyrites, realgar, mispickel, and dimorphine. Orfila,‖ and before him Vogel, of Munich, imply that the leaden chambers in which sulphuric acid is made communicate arsenic to the acid.

Whatever we have said with regard to the American sulphuric acid, applies with still greater force to the commercial chlorhydric acids. That common chlorhydric acid contains chloride of arsenic, is a fact which was long ago observed, and has been fully discussed by Wackenroder,¶ Dupasquier,** Otto,†† and many others.‡‡ We have examined two different samples of chlorhydric acid made in this country. Dilute chlorhydric acid, instead of sulphuric, was used in Marsh's apparatus with 200 grammes of pure Vieille Montagne zinc, and before the hydrogen generated had been passing through the heated reduction-tube fifteen minutes, there appeared in the fine part of the tube a brown deposit, which in an hour increased to a large and distinct mirror of arsenic, readily verified by other tests. Both samples of acid gave the same result, and we may add that, even on a small scale, we found great difficulty in preparing from salt and sulphuric acid a specimen of chlorhydric acid perfectly free from arsenic. The thorough purification of the acid by means of sulphuretted hydrogen, as recommended

* Schweigger's Jour. f. Ch. u. Phys., 1816, XVIII. 283.

† Ibid., 1825, XLIII. 452.

‡ Ann. des Mines, [4.] XIX. 680.

§ Journal f. pr. Ch., 1852, LV. 54.

‖ Ann. d'Hygiène Publique, XXII. 408.

¶ Ann. der Pharm., 1835, XIII. 241.

** Comptes Rendus, 1841, XIII. 630.

†† Ann. der Ch. u. Pharm., 1856, C. 39.

‡‡ See also Ure's Dictionary of Arts, &c., 4th edition, (Boston, 1853,) II. 248, Art. *Muriatic Acid.*

by Otto, is therefore an absolutely necessary preliminary to the use of chlorhydric acid in any examination for arsenic.

From the examination of so few samples of sulphuric and chlorhydric acids, we do not pretend to have established the affirmative proposition, that there is always arsenic in these acids; their impurity was only an incidental difficulty in this research, and we strayed thus far from our main subject, only because of the great importance of trustworthy information upon this point to the pharmacist, and to the chemist who has to do with poisoning cases. Our observations, in connection with the facts long since established regarding the contamination of foreign sulphuric and chlorhydric acids with arsenic, may well lead the pharmacist and the analytical chemist to distrust his acids, till accurate experiments have proved them to be above suspicion; and we believe that careful investigations will hereafter show that arsenic is introduced into pharmaceutical preparations by the acids employed in their manufacture to an extent far greater than would now be credited. The task of the chemist who is called upon to examine a human body or organs of the body for arsenic, is a simple one when the poison is found in its original condition, unabsorbed and unaltered, but in difficult investigations of this kind, when the poison has been absorbed and diffused through a large mass of organic matter which must be destroyed by acids, the precautions insisted upon by Gaultier de Claubry,* and by Galtier,† and other modern toxicologists, should be strictly observed. Not only should all the reagents to be employed be thoroughly tested *à blanc*, but furthermore, an experiment parallel with the actual examination of the suspected organic substances should be carried on with the same reagents in the same quantities, in a similar apparatus, and in all respects under like conditions, upon a quantity of normal animal matter equal to the weight of the suspected substances. In this way only can the chemist avoid the fatal uncertainty consequent upon the employment, in large quantity, of reagents whose purity is not above suspicion.

We return to the examination of other zincs for arsenic. With the same purified acid used in our previous experiments on Pennsylvanian and Vieille Montagne zincs, we tested 200 grammes of *Silesian* zinc, carefully granulated, and perfectly clean. For half an hour, the hydrogen passed steadily through the red-hot reduction-tube without leaving the slightest deposit in the fine tube beyond the heated portion, but on con-

* Briand, et Chaudé, et Gaultier de Claubry, Manuel complet de Médecine Légale, 5me édition, (Paris, 1852,) p. 752.

† C. P. Galtier, Traité de Toxicologie, (Paris, 1855,) Tom. I. p. 362.

tinuing the operation beyond this time (indicated by Otto as sufficient for the testing of the materials *à blanc*), a faint but perceptible mirror gradually formed. This result indicates, first, that this sample of Silesian zinc was not perfectly free from arsenic, and secondly, that it is dangerous to conclude that the zinc and acid, which have given no reaction for arsenic during half an hour in Otto's form of Marsh's apparatus, will therefore give no mirror in the next half-hour, even though no arsenical compound be added to the apparatus. In any delicate examination for arsenic, this is a point to be carefully borne in mind. Our results with this zinc were corroborated by several similar experiments.

The zinc of Rousseau Frères was next submitted to the same test, with the same acid. 75 grammes of this zinc yielded in half an hour a brown deposit, hardly to be called a mirror, although covering a considerable portion (2 centimetres) of the tube. The final result of the experiment was not distinguishable from the result of the test of Silesian zinc.

With the same acid and apparatus, 200 grammes of New Jersey zinc gave a distinct mirror of arsenic, so large in amount, that the arsenic could be easily recognized by its characteristic odor. The mirror began to form at once, and gradually increased during the hour, which was the duration of the experiment.

Having at hand a quantity of the ore from which this zinc is extracted, we extended our search for arsenic to the red oxide of zinc, which is the source of this spelter. Several grammes of the red oxide, finely powdered, were moistened with 30 drops of pure nitric acid, and treated with a measured quantity of pure chlorhydric acid, prepared from common salt and sulphuric acid free from arsenic. The solution, with the very slight residue, was then gently evaporated to a small bulk, with a small measured quantity of Rosengarten's sulphuric acid. The imperfect solution thus prepared was introduced into the flask of our apparatus, whose previous contents of zinc and acid had been thoroughly tested for one hour, and found perfectly pure. In ten minutes a distinct deposit of arsenic was obtained, which in half an hour increased to a large and unmistakable mirror. To prove beyond a doubt that this arsenic came from the oxide of zinc, and not from the acids employed in preparing the solution, we tested in a clean apparatus with fresh zinc and acid, which had been proved pure by a test of one hour in duration, the same quantities of the same acids evaporated together as in the experiment above described. At the end of one hour (the second hour during which the apparatus had been at work) a deposit, perceptible on close inspection, was discovered in the narrow part of the reduction-tube. This deposit was invisible on any cursory examination, and bore no comparison with the very decided mirror of

arsenic obtained in the previous experiment. In two other similar examinations of the red oxide of zinc, we obtained the same strong evidence of the presence of arsenic in this ore, and the associated mineral, Franklinite, yielded, in the single careful test to which we subjected it, a mirror of arsenic sufficient to give the smell and all the other characteristic reactions for arsenic. To obtain satisfactory results, the solution of the oxide must never be heated above 100°, and the small quantity of nitric acid which is used to facilitate solution must be completely driven off before the liquid is introduced into the apparatus.*

If any further evidence of the presence of arsenic in the New Jersey spelter and its ore were needed, it might be found in the following experiment with a zinc which we ourselves prepared by reducing the New Jersey white oxide of zinc with charcoal, in a refractory retort such as are furnished by the dealers in chemical apparatus at Paris. 20 grammes of this zinc, tested in Otto's apparatus with purified sulphuric acid, yielded in five minutes a distinct deposit of arsenic, and in half an hour a large mirror.†

* We have also found arsenic in no inconsiderable quantity in the white zinc oxide, prepared from this ore for use as white paint. Two different samples, bought of authorized dealers, yielded large mirrors of arsenic, many well-marked spots on porcelain, and other of the reactions for arsenic. Moreover, a large precipitate of sulphide of arsenic was produced by sulphuretted hydrogen in their solutions. The qualitative examination of these two samples showed also the absence of lead and copper, and the presence of distinct traces of cadmium, iron, tin, and perhaps of antimony. It has been supposed that the superior quality of the French white zinc oxide was attributable to the presence of sulphur in the American article. To settle this question, we have determined, in two samples of New Jersey white oxide of zinc, the amount of matter insoluble in chlorhydric acid, and the per cent of sulphuric acid which they contained.

	I.	II.
Matter insoluble in chlorhydric acid, . .	0.0006 per cent. . . .	0.00033 per cent.
" " " sulphuric acid, . . .	0.417 " . . .	0.361 "

These impurities are obviously too insignificant to account for the difference between the American and the French zinc-white, a difference probably due to the different mechanical conditions in which the oxide is obtained by the different processes employed in this country and in France. In a letter from Mr. John M. Ordway, we have the results of examinations of these paints made by this chemist in 1855: "The French oxide when dissolved in chlorhydric acid left a little coarse dirt; the colorless solution treated with ammonia in excess gave a very slight white precipitate, soluble in potash and in acids, perhaps alumina. There was also a very faint trace of iron and of sulphuric acid. The American oxide afforded a somewhat colored solution, a little fine soot remaining undissolved. The solution gave a brown precipitate of peroxide of iron when treated with ammonia, and also yielded a considerable precipitate with chloride of barium."

† A further qualitative examination was made of this zinc, as follows. About 10 grammes were dissolved in pure chlorhydric acid; a considerable black residue remained, which was separated, dissolved in nitric acid, and the solution evaporated nearly to dryness. The flocculent precipitate which separated was filtered off and fused before the blowpipe with carbonate of soda which contained no metal. Ductile spangles were obtained,

To ascertain whether the Pennsylvanian and Vieille Montagne zincs were always free from arsenic, we procured and tested another sample of the zinc manufactured at the Pennsylvania and Lehigh zinc works, and a second sample of Vieille Montagne spelter. The Pennsylvanian zinc was, as before, remarkably free from lead, leaving no residue when dissolved in dilute sulphuric acid; but on testing 200 grammes of it in Otto's apparatus with purified acid, it gave in half an hour a slight deposit in the reduction-tube, which in an hour increased to a distinct brown coating. A similar result we obtained in testing the second sample of Vieille Montagne zinc; 200 grammes of it with pure acid yielded a deposit in the reduction-tube, fatal to its use in any delicate experiments. It should be stated, that the external appearance of this spelter indicated very clearly that its quality was inferior to that of the sample first examined. It is obvious from these results, that zinc manufactured in the same works, and from the same ore, may not always contain the same impurities, or rather that it never is to be expected to contain the same percentages of the same impurities. From the nature of the process of reduction, it would naturally be the case that the more volatile impurities should be present in the zinc which distils first in greater quantities than in the zinc which is reduced from the last part of a given charge of ore. Thus it is easy to imagine that the zinc which comes over first should be contaminated with arsenic, while that which is last reduced might be perfectly free from that impurity. The same principle explains the variations in the amount of cadmium contained in different samples of the same spelter, and indeed accounts in great measure for the varying per cents of all the impurities found in different specimens of any zinc, though made by the same process from the same ore.

which on solution in chlorhydric acid, and treatment with terchloride of gold, gave the reaction for tin. To the filtrate from the precipitate just mentioned, pure dilute sulphuric acid was added, and an abundant precipitate separated at once; this precipitate, reduced on charcoal with carbonate of soda, gave a large button, which was dissolved in nitric acid, and tested with chromate of potassa, a voluminous precipitate of chromate of lead separated immediately. No traces of copper were detected.

About 250 grammes of the oxide of zinc had been placed in the retort in which the reduction was to be effected, but only about 50 grammes of zinc were obtained, because the experiment was prematurely ended by the melting of the retort, caused by a combination of the oxide of zinc with the silicates of which it was made. These 50 grammes were only a fourth of the quantity of zinc which 250 grammes of the oxide should yield, and it is interesting to observe that lead and tin, as well as arsenic, accompanied this early product of the distillation. The source of this lead is uncertain; it is not inconceivable that the glaze of the retort should contain it, though to all appearances it was not a lead glaze; but the fact that lead was found in these first portions of the distilled zinc is perhaps none the less interesting, if it did come from the retort. The process of preparing pure zinc by reduction from the oxide on a small scale, is at best very laborious and uncertain. (Compare Neumann in the Abridgment of his Chemical Works by Lewis, London, 1759, p. 116.)

Lastly, we submitted our four specimens of English zinc to the test for arsenic. With purified acid, 200 grammes of the zinc made by Dillwyn and Company began to show a deposit in the reduction-tube within ten minutes of the commencement of the experiment, and in twenty-five minutes this deposit increased to a very perceptible mirror. A similar result was obtained from 200 grammes of the Mines Royal zinc. In fifteen minutes the stream of hydrogen from this zinc began to deposit arsenic in the reduction-tube, and at the end of three quarters of an hour, a thin but perfectly distinct mirror extended over three or four centimetres of the fine tube. On the label which accompanied the specimen of the spelter made at Minera, near Wrexham, it was stated that the zinc was manufactured from silicate of zinc, and we therefore expected to find this spelter purer than the ordinary English zinc made from blende; but, on the contrary, it contained a large amount of lead, and the test for arsenic showed it to contain more of that impurity than either of the two specimens before examined. 100 grammes of the Wrexham zinc began to show a deposit in the reduction-tube in ten minutes from the beginning of the experiment, and at the end of an hour a mirror had accumulated large enough to be identified by the arsenical odor. But of the four samples of English zinc, that of the Messrs. Vivian contained the most arsenic; 200 grammes of this spelter yielded an enormous mirror of arsenic in less than ten minutes, and in a few minutes more a second mirror, large enough to give the characteristic odor. With regard to English zinc, therefore, our observations do not agree with those of Brett,* who states that he has examined many specimens of English and foreign zincs, and could never obtain any indications of arsenic when the sulphuric acid was pure. The explanation of this discrepancy is to be found in the fact, that the test applied by Brett, although essentially Marsh's test, had not the extraordinary delicacy which is insured by Otto's form of Marsh's apparatus.

This question now suggested itself: In presence of an excess of zinc, is not arsenic retained in the black residue (lead) from zinc dissolved in dilute acids, in such a condition, that it is not attacked by the acids or by the hydrogen, and therefore escapes detection? To determine this point, if possible, we dissolved 40 grammes of the Vieille Montagne zinc, which had showed no trace of arsenic by Marsh's test in dilute sulphuric acid, free from arsenic. The residue obtained was washed, treated with chlorhydric and a few drops of nitric acid, and the solution gently evaporated to a small bulk in presence of a little pure sulphuric acid. The mixture thus obtained was washed into the flask of Otto's apparatus, whose previous contents of zinc and acid had

* Philosophical Magazine, 1842, [3.] XX. 404.

been thoroughly tested *à blanc* and found pure. At the end of the second hour, a very slight deposit was discernible on close inspection in the fine tube, but the result was too doubtful to warrant the assertion that arsenic was contained in the insoluble residue. We next tried the same experiment with Silesian zinc, in which Marsh's test had detected arsenic. The residue from 40 grammes of this zinc, submitted to the process just described, produced in the reduction-tube in fifteen minutes a brown deposit, which in half an hour became well marked, and at the end of the hour afforded sufficient evidence of the presence of arsenic in the residue, it being well understood that the zinc and acid used in this experiment had been previously tested for one hour and found pure. The only conclusion to which these experiments point is, that when a given sample of zinc contains arsenic, a portion of that arsenic will escape combination with the hydrogen generated by the solution of the zinc, and will remain in the insoluble residue. It was useless in this connection to examine the residue from New Jersey zinc, because that spelter itself contained arsenic, and its residue contained metallic copper, which would inevitably retain arsenic, as in Reinsch's test. The Pennsylvanian zinc gave no residue with acids.

The absolute necessity of obtaining a zinc free from arsenic for many chemical investigations, renders any process for purifying zinc from arsenic a matter of considerable interest and importance. We therefore tried the process of purifying zinc by fusing it with one fourth of its weight of saltpetre, a method fully described by Meillet,* but previously suggested by Orfila.† 760 grammes of Silesian zinc were finely granulated and mixed with one fourth this weight of saltpetre, by placing the zinc and nitre in alternate layers in a Hessian crucible. The mixture was heated till deflagration ensued, when the melted mass was poured into cold water to separate the slag, caustic potassa, and any arseniate of potassa which might have formed. The washed mass was remelted, and again granulated. The loss of zinc during the process is very large; we obtained only 200 grammes from the original 760 grammes. Of this zinc 170 grammes were tested in Otto's apparatus with pure acid, and in twenty minutes there began to form in the reduction-tube a brownish deposit, which, at the end of three quarters of an hour, was a sufficient evidence of the presence of arsenic. The deposit was as large as that obtained from the same Silesian zinc, before it had undergone this process of fusion with nitre. It has been already stated, under the appropriate head, that this process did not disembarrass the zinc of the sulphur which it contained, and

* Dingler's Polyt. Jour., 1842, LXXXIII. 205; from Jour. de Pharmacie, 1841, p. 625.

‡ Annales d'Hygiène Publique, 1839, XXII. 427.

there seems to be little reason for expecting the complete removal of the arsenic, inasmuch as the fused saltpetre can only be brought in contact with the external surface of the zinc, however finely the metal may be granulated. It is not inconceivable that a trace of arsenic in a zinc should be eliminated by Meillet's process, and that a sample, originally almost absolutely free from arsenic, should be so improved as to afford no perceptible mirror; thus Stein * could not detect arsenic in a sample of zinc purified by this method, but as a general rule it will not be safe to rely upon this process for the conversion of arsenical commercial zinc into zinc fit for use in Otto's apparatus.

On this subject of arsenic in commercial zinc two opposite errors demand notice. On the one hand, not a few chemists have maintained that commercial zinc almost invariably contains arsenic, and that Marsh's test is untrustworthy on this account. Thus Persoz † states that the greater part of the zinc sold in Strasbourg contains arsenic, and in a previous paper,‡ condemning Marsh's process, he remarks with truth, that even distilled zinc may give spots of arsenic. The opinion that all zinc contains arsenic, finds support in the quantitative determinations by Schauefele of the amount of arsenic in French zinc, Silesian zinc, and Vieille Montagne zinc respectively. These determinations have been quoted in almost all the modern text-books, and have had in our opinion much more weight than they are really entitled to. Schauefele determined the arsenic in his samples of zinc by two methods. The first was that of Villain, and consisted in counting the number of arsenic spots obtained from a given weight of zinc, and estimating the corresponding amount of arsenic by means of the following absurd rule: — one milligramme of arsenious acid will give two hundred and twenty-six arsenical spots two millimetres in diameter. The utter unfitness of this process for exact experiments is too obvious to need any illustration. In applying this singular method, Schauefele completely dissolved one kilogramme of zinc in dilute *sulphuric acid*, but in this connection says not a word about the purity of the acid, of which he must have used at least one kilogramme and a half. The second method used by Schauefele was essentially that described by Jacquelain, and consisted in passing all the hydrogen generated by a given weight (from 320 to 800 grammes) of zinc through a solution of chloride of gold; this solution was partially decomposed by the arseniuretted [sulphuretted ?] hydrogen, and when the zinc had been completely dissolved, the chloride of gold solution, which was supposed to contain all the arsenic of the zinc in the condition of arsenious acid, was further decomposed as completely as possible by means of *sulphurous acid*, and the precipitated gold separated by filtration. In the filtrate there

* Jour. f. pr. Chem., 1851, LIII. 40.

† Ann. de Ch. et Phys., [3.] 1844, X. 507, note.

‡ Ibid., [2.] 1840, LXXIV. 432.

still remained a small amount of chloride of gold, which had escaped reduction by the sulphurous acid, and to separate this chloride from the solution of arsenious acid, distillation was resorted to. The retort in which the residue from the distillation remained was washed out with water acidulated with *chlorhydric acid*, and the liquid so obtained was added to the original distillate, through which sulphuretted hydrogen was then passed. The precipitated sulphide was collected on a filter, dried, and redissolved in *ammonia ;* this ammoniacal solution was then evaporated to dryness, and the residue weighed as sulphide of arsenic. As the result of this complicated process, which involves the use of so many different reagents and vessels, Schauefele obtained a quantity of arsenic which varied between two thousandths of one per cent of the weight of the original zinc, in that sample which contained the most arsenic, and two five-thousandths of one per cent in that which contained the least. The weight of the sulphide of arsenic, which was the final result of the analysis, in no case exceeded ten milligrammes. There is no certainty that this very small amount of arsenic was not derived from the acids used in the process, for Schauefele merely states that his sulphuric acid, of which he used a very large quantity, was "absolutely free from arsenic," and the other reagents are said to be pure. The methods by which he insured this absolute purity are not even hinted at, and we therefore have no opportunity of judging for ourselves of the sufficiency of the processes employed to eliminate the arsenic from these reagents, of which two at least almost invariably contain appreciable amounts of that impurity. Quantitative determinations, in which the original weights are kilogrammes, and the final weights milligrammes, are trustworthy only when the processes are short and simple, and the reagents employed are proved to be above suspicion. The process of M. Schauefele was long and complex, and his reagents, so far from being proved to be above suspicion, were in all probability the source of the arsenic which he attributed to the zinc. In the valuable paper which we have before cited, Karsten distinctly states that the Silesian zinc is free from arsenic, basing this statement upon experiments which in their general method closely resembled those of Schauefele; he endeavored to decompose a solution of nitrate of silver by a stream of hydrogen generated by the zinc under examination, but though his process was analogous to that of Schauefele, he was led to the diametrically opposite conclusion. Again, Schauefele's second method was essentially the process which has been thoroughly studied by Jacquelain, who claims for it a delicacy * equal to that of Marsh's process; and yet in Jacquelain's own hands this method detected no arsenic in the specimen of zinc which he examined.† We cannot avoid the conclusion, that the determina-

* Ann. de Ch. et Phys., [3.] IX. 490.

† Ibid., 1843, [3.] VII. 189.

tions given in M. Schauefele's thesis have no general significance, and have gained more credit than they deserve. Our observations conclusively prove that there are zincs in commerce which are not contaminated with arsenic, and it should be noticed that, while one of our pure samples (the Pennsylvanian) was of a zinc which is not yet manufactured in large quantities, the other was a specimen of the Belgian zinc, one of the most common and abundant of the commercial spelters.

We turn now to the discussion of the opposite error, namely, that arsenic is very rarely to be found in the zinc of commerce. On this point we need only quote the strong statements of the highest authorities. Regnault, in the Report* to the French Academy on Marsh's process and its modifications, wrote: "It is easy to procure in commerce zinc and sulphuric acid which give no arsenic in Marsh's apparatus." With the proper understanding of what is here meant by "Marsh's apparatus," this statement is as true now as it was twenty years ago. The committee relied chiefly upon the production of arsenical spots on porcelain, and though they recommended a form of apparatus adapted for heating the arseniuretted hydrogen to redness, yet in this apparatus the reduction-tube was not drawn down to a fine bore beyond the heated portion of the tube, and the committee in their own experiments seem to have preferred the arsenical spots as affording the best evidence of the presence of arsenic. They completely dissolved 500 grammes of commercial zinc in dilute sulphuric acid, and obtained from the hydrogen evolved no sensible arsenical spot; the black residue they did not examine. The test to which we have submitted our acids and zincs is more delicate than that applied by the committee of the French Academy; Otto's apparatus is more sensitive than that used by this committee, and will detect the presence of arsenic in quantities too small to produce sensible spots. It is self-evident that the continuous deposition of arsenic from a stream of hydrogen as it flows steadily through a very fine tube for an hour or more, would exhibit an amount of arsenic too minute to give the slightest perceptible spot in the instant during which the porcelain surface is held in the burning jet of gas. The first reaction is prolonged and accumulative, the second is intermittent and instantaneous. Blancard,† in commenting upon the statement regarding the ease of obtaining pure zinc, which is above quoted from the Report, has remarked with truth, that many zincs of commerce, which give no *spots* by Marsh's apparatus, nevertheless contain sometimes antimony, sometimes arsenic, sometimes both.

The same explanation should accompany the statements of Orfila, with regard to arsenic in commercial zinc and acids. This distinguished toxicologist, in a very valuable paper on "The Means of being assured of the Presence of Arsenic," after remark-

* Comptes Rendus, 1841, XII. 1076, and Ann. de Ch. et de Phys., [3.] II. 159.

† Dingler's Polyt. Jour., 1841, LXXXII. 425, from Jour. de Pharmacie, Sept. 1841, p. 543.

ing * that the sulphuric acid and the zinc of commerce sometimes contain arsenic, nevertheless implies † that he has never obtained decided arsenical spots on porcelain from a commercial sulphuric acid, and subsequently makes this explicit declaration: "I declare that I have made this experiment (the test for arsenic by the production of arsenical spots) more than five hundred times with the sulphuric acid and zinc of commerce, bought of various manufacturers of chemical products, and have only found arsenic *three times*." ‡ Our own experiments confirm the truth of this statement; of all the specimens of zinc which we have examined, not more than two contained enough arsenic to give spots on porcelain, and not a single sample of our sulphuric acid would have afforded that reaction for arsenic. So long as the chemist, employed upon a poisoning case, sought for arsenical spots alone, the little arsenic which his zinc might have contained could do no harm; it is only when important conclusions are to be drawn from more refined experiments, with a more delicate apparatus, that the arsenic so often present in zinc and acids becomes a matter of very serious concern. Our experiments prove that arsenic is contained, not in all samples of commercial zinc, but in a large majority of them; and it will be perceived that we arrive at this result without impugning in the slightest the accuracy of the experiments upon which the very distinguished chemists whose words we have above quoted based opposite conclusions.

General Remarks.—In all commercial zincs metallic lead is the principal impurity, and the only one which deserves quantitative determination, if we exclude those exceptional cases in which the zinc is only an incidental product, or in which a very bad ore yields a zinc contaminated by some special impurity. Such exceptional zincs have only a local interest, for they are produced in very small quantities. The zincs which find their way into commerce in large quantities are the Silesian and the Belgian, the French, English, and American being used at home.

Silesian Zinc.—The greater part of the zinc sold under this name is made from carbonate and silicate of zinc, and from these ores zinc of great purity can be obtained; but wherever blendiferous ores are worked, or zinc-oxide, obtained as an incidental product in some other process, is mixed with the ores used, the resulting zinc may be expected to contain arsenic. The zincs which we may call collectively German, have been more thoroughly studied than any other of the zincs of commerce, and this must be our excuse for having examined so few samples of these spelters. It had been established by the analyses of Karsten, Wackenroder, Kerl, and others, that lead was their chief impurity, and that cadmium often occurred in them in noticeable quantities. We have demonstrated the presence of minute quantities of sulphur and arsenic in

* Annales d'Hygiène Publique, 1839, XXII. 404. † Ibid., 411. ‡ Ibid., 424.

those samples which we have examined, of the spelters which are produced in the largest quantity from the best ores. An extended examination of the zincs produced on a small scale at different works throughout Germany, would in all probability detect the same impurities; * but the labor of the investigation would be out of all proportion to the interest and importance of the facts to be observed.

Belgian Zinc. — There is a very noticeable difference in the purity of different samples of Belgian zinc. The ore is a mixture of carbonate and silicate of zinc, and yields with care an excellent spelter, which contains but a small amount of lead and no arsenic. We have found other samples of the zinc that were not free from arsenic, which they probably derived from the blende and its associated minerals, which occur with the silicate and carbonate of zinc constituting the great bulk of the ore. Careful selection of the ore is evidently necessary for the purity of the resulting metal.

English Zinc. — Much of the English zinc is made from blende, and is therefore more impure than the zinc of other countries made from better ore. Our analyses show that the English zincs, on the average, contain more lead than any spelter except the Silesian, and we also found much more arsenic in them than in any other zinc, except perhaps the New Jersey. One specimen of English zinc yielded a clear but slightly colored solution in dilute sulphuric acid, and our subsequent analysis gave no explanation of this color; its general appearance suggested the possible presence of some organic matter in the solution, and we mention the circumstance, because it is the only clew which we have been able to find to Miller's remark previously quoted, namely, that zinc contains a peculiar carbonaceous matter.

American Zinc. — The New Jersey zinc is made from the red oxide of zinc, mixed with Franklinite, and from the published analyses of these minerals the natural inference would be that they should yield a zinc of excellent quality. Accordingly, we found that our sample of this spelter contained less lead than any except the Pennsylvanian zinc; but on carrying further the analysis of the zinc, we were surprised to detect the presence of copper in a quantity sufficient to admit of quantitative determination. The analyses of the ore afford no clew to the source of this copper, and we are unwilling to believe that it is a natural and necessary admixture in zinc prepared from this ore. The amount of arsenic contained in this spelter was unusually large, but is fairly derived from the ore, in which we detected distinct traces of arsenic. This zinc was also contaminated with sulphur, carbon, and tin, and on the whole was one of the most impure spelters which we examined.

* For example, it would be difficult to imagine how a zinc free from arsenic could be made from the oxide collected on the "Zinkstuhl" in the process formerly used in the Hartz, or from the arsenical blende now worked at Freiberg (Saxony).

The purest of all the zincs which we have analyzed is that manufactured at the Pennsylvania and Lehigh Zinc Works, Bethlehem, Pennsylvania. This spelter dissolves in dilute sulphuric acid without leaving any appreciable residue, and therefore contains no lead; indeed, a trace of cadmium is the only impurity whose presence in the zinc we could confidently assert. The ore from which this spelter is made is the hydrated silicate of zinc (electric calamine), and it is not surprising that this mineral should yield zinc of singular purity, if the ore be carefully selected. We have stated above that our first sample of this zinc was free from arsenic, but that the second sample was not pure in this respect. At these works the oxide of zinc is manufactured, as well as the metal, and we learn from a letter addressed to Professor Brush by Mr. Wharton, the director of the works, that the crust from the oxide furnaces has now and then been worked into spelter, and that the ore used in making the oxide is less carefully selected than that which goes to the spelter-furnaces, and is much more likely than the latter to contain both blende and pyrites. This fact may account for the occurrence of arsenic in some specimens of this spelter, while the greater part of it, manufactured from carefully selected silicate of zinc, is perfectly free from that impurity. There seems to be no reason why zinc of uniform purity should not be obtained from this excellent ore.

Pure Zinc. — We have already referred to the difficulty of obtaining a pure zinc by reducing it from the oxide on a small scale; nothing but the direst necessity could induce us again to attempt the operation, although it has been recommended by many high authorities. Nevertheless it is by no means difficult to prepare a pure oxide of zinc, and manufacturers of pure chemicals, working on a larger scale than it is practicable for the chemist to do, might undoubtedly prepare from this oxide at moderate cost a really pure zinc. There are some processes of chemical analysis in which the contamination of zinc with metallic lead is a matter of importance, because it affects the accuracy of the results; but in these cases the difficulty can generally be avoided by discarding zinc altogether, and resorting to other methods of analysis. But in order to use Marsh's process for the detection of arsenic, the chemist must procure zinc free from arsenic, and there is no escape from this necessity; redistillation will not disembarrass zinc of its arsenic, and the process of reducing zinc from a pure oxide is very laborious and uncertain; how then can zinc free from arsenic be obtained? There is but one satisfactory answer to this question. Pure zinc might certainly be made from the oxide by the manufacturing chemist, but at present the zinc labelled "pure" by those who sell chemicals is not to be relied upon, and the chemist must therefore test samples procured from the dealer in metals, until he finds a specimen of the pure zinc which is manufactured on a large scale, and is to be obtained in commerce.

Note on the Precipitation of Zinc from Acid Solutions by Sulphuretted Hydrogen. — In the earlier steps of this investigation, we were somewhat embarrassed by the precipitation of sulphide of zinc, when sulphuretted hydrogen was passed for several hours through solutions of sulphate of zinc containing a considerable excess of sulphuric acid. In studying the best method of avoiding the difficulty, we made a series of experiments which seem to us to reconcile statements of previous observers which were apparently at variance, and to put the subject in a clearer light than that in which former observations had left it. From nine experiments with an aqueous solution of sulphate of zinc acidulated with sulphuric acid, and nine similar experiments with chloride of zinc and chlorhydric acid, Calvert * inferred that "zinc, even in very acid liquors, was freely and sometimes completely precipitated from them by sulphuretted hydrogen," and that "the old method for the separation of salts of zinc from those of copper must in future be rejected as completely inexact." On the other hand, Grundmann † has deduced from four experiments with a solution of sulphate of zinc, acidulated with chlorhydric acid, a rule for the prevention of this precipitation of zinc by sulphuretted hydrogen, and he also maintains that the separation of copper or cadmium from zinc can be satisfactorily performed by repeating two or three times the precipitation of the copper or cadmium by sulphuretted hydrogen, and taking care to maintain in the solution a certain specified excess of acid. Grundmann used in each of his four experiments, 10 c. c. of a solution of sulphate of zinc (containing 0.2118 gram. of oxide of zinc in 10 c. c.), and 100 c. c. of water; to this mixture he added in the first experiment 1 c. c. of chlorhydric acid (Sp. Gr. = 1.1.); in the second, 2 c. c.; in the third, 3 c. c.; and in the fourth, 4 c. c. In the first experiment all the zinc was precipitated, but in the last none. The following tables contain a series of experiments which we devised in order to prove what might be inferred from some of Calvert's experiments; namely, that this precipitation of zinc by sulphuretted hydrogen was dependent, not so much upon the relation of the amount of free acid to the zinc-salt in the solution, as upon the degree of dilution of the solution, and that the mere addition of water might determine this precipitation in a solution which remained perfectly clear before such dilution. For convenience of comparison, we have used in the experiments of Table I. chlorhydric acid, and a solution of pure chloride of zinc of the same strength, and in the same quantities which were employed by Grundmann, but have substituted for the sulphate of zinc which he used chloride of zinc, in order to avoid bringing together in the same solution the sulphate of zinc and free chlorhydric acid, — a complication which seemed unnecessary and undesirable.

TABLE I.

	H Cl. Sp. Gr. = 1.1.	Zn Cl Solution; .2118 gram. Zn O in 10 c. c.	Water.	Remarks.
1	1 c. c.	10 c. c.	100 c. c.	No precipitate at the end of half an hour; after 15 hours an abundant but not complete precipitation.
2			200 c. c.	At the end of 15 hours all the zinc was precipitated.
3			500 c. c.	The precipitation began in two hours, and when next observed (at the end of 24 hours) was complete.
4	2 c. c.	10 c. c.	200 c. c.	No precipitate in 4 hours; in 24 hours there was a large but not complete precipitate.
5			500 c. c.	No precipitate in 1 hour; after 18 hours an abundant but not complete precipitation.
6			1000 c. c.	In 18 hours all the zinc was precipitated.
7	3 c. c.	10 c. c.	100 c. c.	H S was passed three times, and the last time during 18 consecutive hours; no precipitate.
8			200 c. c.	H S was passed twice; the last time during 12 consecutive hours; no precipitate.
9			500 c. c.	Began to precipitate in ¾ hour; in 18 hours there was a large but not complete precipitation.
10	4 c. c.	10 c. c.	500 c. c.	H S was passed three times, and the last time during 18 consecutive hours; no precipitate.
11			1000 c. c.	H S was passed twice, during 15 hours each time; no precipitate.
12			1500 c. c.	Began to precipitate in 1 hour, and gave a dense but incomplete precipitate.

* Report of British Association for Adv. Sci., 1855, p. 51.

† Jour. f. pr. Ch., 1858, LXXIII. 242.

TABLE II.

	H Cl. Sp. Gr. = 1.1.	Zn Cl Solution; 6.6272 gram. Zn O in 10 c. c.	Water.	Remarks.
1	3 c. c.	5 c. c.	0	H S was passed for several hours, and the solution saturated with the gas stood over night; a slight cloudiness, not amounting to a precipitate, appeared.
2	5 c. c.	5 c. c.	0	Do. do. do.
3	8 c. c.	5 c. c.	0	Do. do. do.
4	3 c. c.	5 c. c.	25 c. c.	H S was passed steadily for 24 hours. Precipitate larger than before dilution, but still very slight.
5	5 c. c.	5 c. c.	25 c. c.	Do. do. do.
6	8 c. c.	5 c. c.	25 c. c.	Do. do. do.
7	10 c. c.	5 c. c.	0	H S was passed steadily for 28 hours, producing a distinct cloudiness.
8	15 c. c.	5 c. c.	0	H S produced in 6 hours a marked cloudiness, which at the end of 40 hours had somewhat increased.
9	20 c. c.	5 c. c.	0	H S was passed steadily for 28 hours, producing a distinct cloudiness.
10	25 c. c.	5 c. c.	0	H S was passed 6 hours and over night; a perceptible but very small precipitate.
11–15	30–50 c. c.	5 c. c.	0	Five experiments, of which the results were not distinguishable; H S was passed thoroughly, and in each case a very slight precipitate was produced.
16	10 c. c.	40 c. c.	0	H S was passed steadily for 40 hours, producing a very slight precipitate.

The experiments of Table I. sufficiently prove that this precipitation is caused by too great dilution, and that an amount of free acid which prevents the precipitation of zinc from a concentrated solution becomes insufficient when the solution is very much diluted. The precipitates produced in dilute solutions are readily soluble in strong acid. This precipitation of zinc from acid solutions seemed a more serious difficulty to Calvert than it did to Grundmann, because Calvert's solutions were, on the average, very much more dilute than Grundmann's, both with regard to the acid and to the zinc-salt which they contained. Calvert's strongest solution contained only as much free acid as Grundmann's weakest, and hence in Calvert's experiments there was always a free precipitation of zinc which was often complete, while Grundmann soon found a limit beyond which the precipitation was too trivial to be noticeable.

The precipitates obtained in the experiments of Table II. were so minute, that they could not be certainly proved to be sulphide of zinc, and were utterly insignificant in comparison with the amount of zinc-salt contained in the very concentrated solutions. The gradual increase in the amount of free acid from the first experiment to the fifteenth, did not prevent the formation of this slight precipitate, and in the sixteenth experiment, the cloudiness produced was no greater than in the fifteenth. In a concentrated solution, therefore, a small amount of free acid will practically prevent the precipitation of the zinc. We have observed that in almost all cases, even when there is no actual precipitate, sulphide of zinc is deposited on any scratches on the sides of the beaker, and forms an adhering ring at the end of the tube which delivers the sulphuretted hydrogen. With regard to the value of the process of separating copper or cadmium from zinc by means of sulphuretted hydrogen, it seems perfectly possible to avoid such a dilution of the solution under treatment as would cause the precipitation of the zinc, without falling into the opposite and equally dangerous error of having too much free acid in the solution. Martin * has shown that copper, and several other metals of the same group, are not completely precipitated by sulphuretted hydrogen in presence of a certain excess of concentrated acid. Between these two extremes, it is undoubtedly possible to find a safe mean, which may be rendered doubly sure by resorting to the tedious reprecipitation recommended by Grundmann and by Fresenius; † but in most cases other methods of analysis can be used with less trouble and greater accuracy.

* Jour. f. pr. Ch., 1856, LXVII. 371.

† Anleitung zur Quantitativen Chem. Analyse, 4te Aufl., 1858, p. 423.

CAMBRIDGE, *May*, 1860.

IV.

Remarks on the Latest Form of the Development Theory.

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It is a familiar truth in palæontology, that the various races or species of animal and vegetable life which now tenant the earth, or have formerly tenanted it, did not originate all at once, but have been introduced at different and widely separated epochs. Those of which the remains are entombed in the earlier fossiliferous strata are now all, or nearly all, extinct; only a very few among the Invertebrates have living representatives at the present day. And as the process of extinction was not sudden or sweeping, but gradual and protracted, so the new species appeared in succession, after long intervals of time, to fill the vacant places. "It appears," to adopt Sir C. Lyell's language, "that from the remotest periods there has been ever a coming in of new organic forms, and an extinction of those which pre-existed on the earth; some species having endured for a longer, others for a shorter time; while none have ever reappeared after once dying out." The species which are now in existence belong, geologically speaking, to comparatively recent times; indeed, none of the higher orders among them are found in a fossil state at all.

Only two theories are possible as to the origin of all the species which have thus been successively introduced upon the earth. The one refers the beginning of each to a special act of creative power. The work of creation, upon this view, was not begun and ended at one time, but has been frequently renewed and extended, no period being without some manifestations of it in the appearance of new forms of life. This doctrine rests upon the fact, confirmed by all observation, that, in the ordinary process of reproduction, each species gives birth only to those of its own kind. It is contrary to

universal experience, in the case of well recognized and perfectly distinct species, that fertile offspring, capable of continuing their own race, should be specifically different from their parents. Accordingly, if a new form or species appears, it cannot have been produced by ordinary generation, but must have been specially created.

The other theory, resting mainly upon obscure and anomalous cases, or upon processes supposed to be of so great length that man cannot have witnessed the beginning and end of them, assumes that various species have been developed out of one another by ordinary descent, the progeny appearing, either immediately or after many generations, specifically different from their parents or ancestors. According to this view, the multiplication of species takes place by a process perfectly analogous to that of the multiplication of individuals of the same species, though it is more infrequent or requires a greater length of time for its completion. This is the Development Theory, so called, which has been maintained, with various modifications, by Maillet, in a work called the "Telliamed," by the French naturalist, Lamarck, by the English author of the "Vestiges of Creation," and in its latest form by Mr. Charles Darwin. The earlier forms of it have been rejected by the wellnigh unanimous verdict of the scientific world; the latest has been urged with so much ability and candor, and has already found so many adherents, that it merits distinct and respectful consideration.

Mr. Darwin's theory of the origin of species by development really consists of five distinct steps or processes, which need to be sharply distinguished from each other, though two or more of them are often confounded under the same name.

1. *Individual Variation.* — It is a well-known fact, that individual plants and animals are occasionally found to vary by slight peculiarities from the general type of the race or breed to which they belong. The offspring is made a little bigger or a little smaller than its parent; or some organ, member, or limb is abnormally repeated or deficient, or wrongly placed, or unusually developed whether by excess or defect.

2. *Inherited Variation.* — Generally, these abnormal traits are found only in the individuals in which they first appear, the offspring of these reverting immediately to the ancestral or common type. Sometimes, they are continued by descent through two or three generations, and then finally disappear. Less frequently, if at all, they are continued by inheritance indefinitely, so as to become the distinguishing mark of a peculiar breed. Mr. Darwin's theory rests exclusively upon those which are thus *perpetuated* by inheritance; "any variation," he says, "which is not inherited is unimportant for us."

3. *Cumulative Variation.* — One peculiarity having been perpetuated by inheritance, it is assumed that another may be superinduced upon it by a perfectly analogous

process, and then a third, and so on indefinitely; so that the divergence from the parent stock, at first slight and unimportant, may be extended as far as we please, till it will bridge over the interval between the two extremes of animal life. Thus, if time enough be allowed for the process, we can account for the development of man himself out of a zoöphyte.

4. *The Struggle for Life.* — Every species of animal and vegetable life, the human species included, can multiply its own numbers without end, this capability being always exercised according to the law of a geometrical progression. If it were exerted to the utmost, without any check from external circumstances, any species might be so multiplied that it would soon need to occupy the whole face of the earth. But as this power is possessed by all, there must be perpetual competition between them for the ground and for food. A battle for existence is constantly going on, the stronger species always tending to push out the weaker, the one better adapted to the locality or the strife forever usurping the place of its less qualified rival. Hence the extinction of the countless races whose existence is now known only from their remains imbedded in the rocks.

5. *Natural Selection.* — Through the three processes of Variation, Nature is perpetually furnishing fresh combatants for this unceasing strife; and any peculiarity, however slight, of one of the new races, may be a source of strength or weakness, and thus lead to victory or defeat in the contest, — that is, to the preservation or extinction of one or more parties to it. Each variation, if it be an improvement in the adaptation of an organ to a function, or of a species to its locality or environment of circumstances, will tend to preserve the race; if the opposite, to kill it out. Thus the nicest adaptations of means to ends are accounted for, without any necessity of supposing that they were intentional or designed. The success, however insured, of any new-comer over its immediate competitor, is often attended with a train of consequences fatal to the continuance of a whole set of pre-existent species, and favorable to the ultimate introduction of new ones in their place.

It appears from this analysis, that the appellation which Mr. Darwin has given to his own theory is a misnomer. He calls it "the Origin of Species *by Means of Natural Selection*, or the Preservation of Favored Races in the Struggle for Life." But it is evident that *the origin* of species is fully accounted for, if at all, by the first three steps of *Variation*, which alone explain the introduction and indefinite multiplication of new forms of life; of the two remaining steps, one, the Struggle for Life, is of use only to account for *the extinction* of species formerly in being, and the other, Natural Selection, is adduced merely to explain that nice adaptation of means to ends, so ap-

parent throughout the animal and vegetable kingdoms, which has been held to prove design, and so to evince the intelligence of the Creative Cause. A theorist who denies the necessity of any intervention of such a Cause at any period subsequent to the introduction of the first poor germ of life upon the earth is, of course, bound to show how these adaptations became so numerous and so perfect; and Natural Selection is the very ingenious hypothesis which Mr. Darwin has framed for this purpose.

The state of the evidence upon each of these five points, and the bearing of each upon the main question, may be briefly summed up as follows: —

1. Individual Variation is the one admitted fact upon which the whole theory rests, but which, considered in itself alone, does not aid us at all in the attempt to explain the introduction of new *races* of being. It accounts for the appearance of new *individuals.*

2. Inherited Variation is more questionable, the general rule undoubtedly being that peculiar and anomalous features — deformities, monstrosities, or *lusus naturæ*, as they are often termed — are either not transmitted at all by descent, or disappear in the course of two or three generations. Whether they disappear because a congenital peculiarity, like an acquired one, such as a scar, a callus, or a stiffened joint, not affecting the organs of reproduction, has no tendency to reproduce itself in the offspring; or because the monstrosity is itself a sign or a consequence of some weakness or defect of constitution, whereby the varying individual is rendered less capable than others of continuing its kind; or because the necessary crossing of the altered breed with one that is unaltered soon reduces the abnormal growth to nothing; or that breeding in and in, which results from the avoidance of crossing, so weakens the stock that it soon ceases to be fertile; or whether several of these causes combined hasten the work of extinction, — certain it is that Nature makes haste to eliminate these departures from type, and to preserve her own original stamp unchanged. Art may to some extent, and with much painstaking, counteract Nature, laboring to preserve and continue the abnormal developments which happen to suit man's convenience or fancy through enforced isolation and regimen, diligent culture, or multiplying or changing the food; but the very necessity of adopting these expedients shows the *tendency* of Nature to be the other way, towards the extinction of the forced growth. As Mr. Darwin himself remarks, "sterility is the bane of our horticulture;" and with all the care and skill of the most expert breeder of cattle, the progeny of his best specimens often disappoint his expectations, and show an unmistakable tendency to revert and degenerate.

Of course, it is admitted that what are called permanent "Varieties" exist, which, with but few precautions, may be made to breed true; but that these so-called "Varie-

ties" originated in Individual Variations perpetuated by inheritance, or that they were not just as much original or special creations as the Species themselves under which they are ranked, is matter only of hypothesis and conjecture. With respect to the numerous "Varieties" of our dogs, horses, sheep, goats, pigeons, &c., Mr. Darwin "believes," or is "doubtfully inclined to believe," or is "fully convinced," that they came either from one wild stock, or from several; or he "can form no opinion" on the subject. But science cannot be made to rest on mere "opinion." That we cannot trace the history of these Varieties *ab origine* is confessed. We cannot trace the stream to the fountain-head; but we can follow it far enough to be sure that it has remained unchanged for thousands of years. The greyhound existed under the form which it now bears at least as early as some of the oldest sculptures in Egypt; and various "breeds" of pigeons were pets of the Pharaohs about five thousand years ago.

3. But with whatever success the doctrine of Inherited Variation may be applied to explain the existence of *Varieties*, it is certain that the origin of *Species* can be accounted for on the Development Theory, if at all, only by Cumulative Variation,— that is, only by supposing a vast number of Inherited Variations to be successively superinduced one upon another. Doubts have been raised upon this point only on account of ambiguity in the meaning of words, or from want of agreement as to the principles of classification. Many races, both of animals and vegetables, appear to be so nearly allied to each other, that certain naturalists consider them as mere Varieties; others persist in considering them as so many distinct Species. Mr. Darwin himself remarks (pp. 49, 50, Am. ed.), that the distinction between Varieties and Species is "entirely vague and arbitrary"; and says, in reference both to plants and animals, "that many forms, considered by highly competent judges as Varieties, have so perfectly the character of Species, that they are ranked by other highly competent judges as good and true Species." Fortunately we do not need, so far as our main question is concerned, to enter into the intricacies of this discussion. The advocates of the Development Theory undertake to prove that *all* Species of animals, even those differing most widely from each other, "have descended from at most four or five progenitors, and plants from an equal or lesser number." Putting aside altogether, therefore, the much debated question whether the several races of men are only Varieties, or are so many distinct Species, and the same question with respect to dogs, there is no doubt that men and dogs belong respectively to different Species. And generally, putting aside the question whether the offspring of certain races when crossed are entirely sterile or only partially so, there is no doubt that animals or plants belong to distinct Species when they cannot be crossed or made to interbreed at all. It is enough to say, then, that only Cumu-

lative Variation — and that of a vast number of successive steps — will account for the common origin of animals which will not copulate with each other, or of plants which cannot be crossed.

Now, on this cardinal point, which contains the essence of the Development Theory, since all the other questions involved in it are of no substantive importance, so far as what may be called the Philosophy of Creation is concerned, the direct evidence fails altogether, and we are left exclusively to the guidance of conjecture and analogy and estimates of what is possible for all that we know to the contrary. It is not even pretended that we have any direct proof, either from observation or testimony, that two Species so distinct that they will not interbreed have yet sprung from common ancestors. On the contrary, Mr. Darwin's own supposition is, that the process of developing two entirely distinct Species out of a third is necessarily so gradual and protracted as to require a *quasi* eternity for its completion, so that only a small portion of it could have been accomplished during the limited period of man's existence upon the earth.

In the absence of any direct proof, then, it remains to be inquired if there are sufficient grounds of probability, reasoning from analogy and the principles of inductive logic, for believing that all Species of animals and plants may have originated from three or four progenitors. In speaking of the amount and frequency of Individual Variation, Mr. Darwin and his followers abuse the word *tendency*. After heaping up as many isolated examples of it as they can gather, they assert the legitimate inference from such cases to be, that the species *tends* to vary, leaving out of view the fact that a vastly larger number of individuals of the same species do not vary, but conform to the general type. And though only one out of a hundred of these Individual Variations is transmitted by inheritance, yet, after collecting as many instances of such transmission as they can find, they affirm that a Variation *tends* to become hereditable. But it is not so. *Tendency* is rightly inferred only from the *majority* of cases; a small minority of favorable instances merely shows the *tendency* to be the other way. Thus, the cars do not *tend* to run off the track, although one train out of a thousand may be unlucky enough to do so; but the general law is, that they remain on the track. Otherwise, people would not risk their lives in them. So a considerable number of children have been born with six fingers on each hand, and a still greater number with harelips. And yet we say that the *tendency* is for each hand to have only five fingers, and for the upper lip and palate to be closed. The advocates of the Development Theory violate the first principles of inductive logic, by founding their induction not, as they should do, on the majority — the great majority — of cases,

but on the exceptions, the accidents. Their whole proceeding is an attempt to establish a philosophy of nature, or a theory of creation, on anomalies, — on rare accidents, — on *lusus naturæ.*

This single objection is fatal to Mr. Darwin's theory, which depends on the accumulation, one upon another, of many successive instances of departure from the primitive type. For if even Individual Variation appears only in one case out of a hundred, — and all naturalists will admit this proportion to be as large as the facts will warrant, — and if, out of the cases in which it does appear, not more than one in a hundred is perpetuated by inheritance, then should a second Variation happen, what chance has it of leaping upon the back of one of the former class? The chance is one out of $100 \times 100 \times 100 = 1{,}000{,}000$. And the chance of a third Variation being added to a second, which in turn has been cumulated upon a first, will be one out of 100 raised to the fourth power, or 100,000,000. It is not necessary to carry the computation any further, especially as Mr. Darwin states (page 90) that the process of development can be carried out "only by the preservation and accumulation of infinitesimally small inherited modifications." Of course, the interval between two Species so distinct that they will not interbreed could be bridged over only by a vast number of modifications thus minute; and on this calculation of the chances, the time required for the development of *one* of these Species out of the other would lack no characteristic of eternity except its name. But the theory requires us to believe that this process has been repeated an indefinite number of times, so as to account for the development of *all* the Species now in being, and of all which have become extinct, out of four or five primeval forms. If the indications from analogy, on which the whole speculation is based, are so faint that the work cannot have been completed except in an infinite lapse of years, these indications practically amount to nothing. The evidence which needs to be multiplied by infinity before it will produce conviction, is no evidence at all.

4. What is here called the "Struggle for Life" is only another name for the familiar fact, that every Species of animal and vegetable life has its own Conditions of Existence, on which its continuance and its relative numbers depend. Remove any one of these Conditions, and the whole Species must perish; abridge any of them, and the number of individuals in the Species must be lessened. The intrusion of a new race which is more prolific, more powerful, more hardy, or in any way better adapted to the locality, may gradually crowd out some of its predecessors, or restrict them within comparatively narrow bounds. Thus the introduction of the Norway rat has banished the former familiar plague of our households and barns from many of its old haunts, and probably reduced the whole number in this Species to a mere fraction of what it once was.

Civilized man also has successfully waged war against many ferocious or noxious animals, and probably exterminated some of them. But the appearance of a rival or hostile race is not the only cause of such diminution or extinction. A change in the physical features of a given district may partially or entirely depopulate it, without the necessary introduction of any new-comers. The drying up or filling up of a lake is necessarily fatal to all its aquatic tribes. The gradual submergence of an island or a continent must exterminate, sooner or later, all the native Species which were peculiar to it. And at the utmost, the failure of any Condition of Existence, whatever may be its character, only leaves vacant ground for the future introduction or creation of new forms of life, without tending in the slightest degree to bring such new forms into existence.

5. Natural Selection, also, as already remarked, has nothing to do with the *origin* of Species, and, in its abstract form, is only the statement of a truism. Of course, when two or more Species crowd each other, the more prolific or the more vigorous, other things being equal, is more likely to gain possession of the disputed ground, and thus to diminish the numbers of the other, or oblige it to migrate, or, in rare cases, to kill it out altogether. But this last supposition is a conceivable rather than a probable result. All observation goes to show, that every Species retains a very persistent hold upon life, however feeble may be the tenure of existence for its individual members. Its numbers may be materially diminished; it may be forced to shift its ground, and to suffer in consequence some slight change in its habits; (Mr. Darwin himself tells us of upland geese and of woodpeckers where there are no trees;) it may be driven into holes and corners; but somehow it still survives. Utter extinction of a Species is one of the rarest of all events; not half a dozen cases can be enumerated which are known to have taken place since man's residence upon the earth. And these, surely, are a very insufficient basis on which to found a theory embracing all forms of life. Yet man is the greatest exterminator the world has ever known. His physical powers, coupled with the use of reason by which they are multiplied a thousand-fold, enables him to wage internecine war with comparative ease against nearly every race that molests him. Only the insect tribes, through their immense numbers and their littleness, can successfully defy him; and these not always. In *his* Struggle for Life, all other creatures, animal or vegetable, must retreat or perish. Yet how few has he rooted out altogether! But the Development Theory requires us to believe that this process of extinction, guided by Natural Selection, has been repeated wellnigh to infinity. Not only all the races which are now found only in their stone coffins, but countless others, — "the interminable number of *intermediate* forms which must have

existed" as connecting links, and a still greater crowd of other Varieties not intermediate, but gross, rude, and purposeless in their formation, — the unmeaning creations of an unconscious cause, — must all have perished, each through its own peculiar repetition of a series of events so infrequent that we can hardly compute the chances of their happening at all.

It is easy to see why the extermination of a Species, even upon the conditions of Mr. Darwin's theory, should be so infrequent. He holds that all the races which have originated upon the earth since the primeval act of creation first grudgingly threw only four or five seeds of existence into the ground, have been shaded into each other by gradations so slight as to be nearly imperceptible. Differing so slightly from each other, the advantage possessed by any one of them in the Struggle for Life must have been almost indefinitely small. But a peculiarity important enough to preserve those who have it, while whole Species must die out because they have it not, cannot be thus trifling in character. It must have been one of grave moment; not a slight Variation, but a jump. The successive development of new races — itself, as we have seen, an extremely slow process — must have been continued through numerous steps, before the divergence resulting from it could have been serious enough to enable one of the divergent stocks to overcome and exterminate the other. Numerous Species of the same genus now coexist, often within the bounds of a not very extended territory, without any one of them showing any tendency to supplant or exterminate another. Thus, South Africa is the country *par excellence* of the antelope; about fifty species of this animal have been found there, many of them very abundant, notwithstanding the numerous *Carnivora* that prey upon them, and yet none of them showing any tendency to die out before civilized man came thither and brought gunpowder along with him.

Natural Selection can operate only upon races previously brought into being by other causes. In itself, it is powerless either to create or exterminate. In the Development Theory, its only function is, when the number of different Species is so far multiplied that they crowd upon each other, and the extinction of one or more becomes inevitable (if we can conceive of such a case), then to make the *selection*, or to determine which shall be the survivors and which the victims. As individuals of the same Species, the same Variety, and even of the same flock, certainly differ much from each other in strength, swiftness, courage, powers of endurance, and other qualities, Natural Selection has an undoubted part to play, when the struggle comes for such a flock, in determining which of its members shall succumb. But that it ever plays a corresponding part in the grand contest of Species imagined by Mr. Darwin, is a supposition

resting upon no evidence whatever, but only upon the faint presumption afforded by the fact, that certain Species at widely separated times have become extinct, through what causes we know not; and therefore, for all that we know to the contrary, Natural Selection may have had something to do with their disappearance. This is to found a theory, not upon knowledge, but upon ignorance. If such reasoning be legitimate, we are entitled to affirm that the moon is inhabited by men "whose heads do grow beneath their shoulders." It may be so, for all we know to the contrary.

This review of the state of the evidence upon each of Mr. Darwin's five points is enough to show that the testimony fails entirely just where it is most wanted. Facts and arguments are accumulated where they are of little or no avail, because the conclusions to which they tend, when properly limited and qualified, are admitted and familiar principles in science. But the theory of the Origin of Species *by Cumulative Variation*, which is all that is peculiar to this form of the transmutation hypothesis, rests upon no evidence whatever, and has a great balance of probabilities against it. Individual Variation, the Struggle for Life, and Natural Selection, each within clearly defined limits, are acknowledged facts, which still leave the main question in the philosophy of creation precisely where it was before; and even the doctrine of Inherited Variation relates only to the *origin of Varieties*, which is a distinct question, and one of subordinate importance and interest, except to naturalists. Mr. Darwin has invented a new scheme of cosmogony, and finds that, like other cosmogonies, it is a blank hypothesis, not susceptible either of proof or disproof, and needing an eternity for its development. There is nothing new in such a speculation of what is possible in an infinite lapse of years. This latest form of the speculation has no advantage over the one first propounded some three thousand years ago; — that a chaos of atoms, moving about fortuitously in infinite space, may have happened, in an eternity, to settle into the present kosmos; for the chance of order and fitness is at least one out of an infinite number of chances of disorder and confusion; and in an infinite series of years, this solitary chance must sooner or later be realized. Mr. Darwin begins, not with a crowd of inorganic atoms, though consistency required him to do so, but with four or five primeval organisms very low down in the scale, — say zoöphytes and mollusks; and supposes these to multiply and to vary their organization at random, each Variation, if an improvement, being preserved, and if useless or injurious, being killed out by Natural Selection; and thus, in an eternity, the present kosmos of animal and vegetable life may have been perfected, not exactly out of chaos, but out of very few and poor rudiments, without the necessary intervention anywhere of an intelligent Creative Cause.

Every such speculation must be rejected, because it is self-contradictory. It professes to develop a Theory of Creation, — to explain the beginning of things; and in order to do so, it is obliged to assume that the present or ordinary succession of phenomena, the common sequence of causes and effects which we every day witness, has continued from eternity; — that is, that there never was any Creation, and that the universe never began to be. It professes to untie the knot, and ends by denying that there is any knot to untie. Mr. Darwin is too imaginative a thinker to be a safe guide in natural science; he has unconsciously left the proper ground of physics and inductive science, and busied himself with questions of cosmogony and metaphysics.

We are at liberty, then, to consider the relations of this Development Theory to the great doctrines of philosophy and theology, without shifting the question or seeking to place it upon any other grounds than those upon which the author himself bases it; — above all, without seeking to build up an argument *ad invidiam*, a purpose which is here emphatically disclaimed.

Most interesting and important among these relations is its bearing upon the doctrine of Final Causes. The denial of such Causes — that is, the doctrine that purpose, intention, or design is nowhere discoverable in organic nature — has been reproachfully urged against some naturalists, on account solely of the tendency of such denial to weaken the arguments of the theist. Of course, it does have such an effect, for what has ever been the principal, most intelligible, and most popular argument for the being of a God rests entirely upon the assumption that adaptations, especially if nice and complex, *prove* design, or must have been intended. But it is a mistake to suppose that Final Causes have no use or meaning in philosophy and science, apart from this application for a theological purpose. Aristotle first described and designated them, distinguishing them from the three other sorts of causes (Material, Formal, and Efficient), without even hinting at their bearing on the doctrine of the theist; while Harvey successfully used the assumption of a Final Cause as an instrument of discovery, and Cuvier did the same; and it is in reference only to such use, viz. as instruments of physical research, that Lord Bacon condemned the study of Final Causes.

And here it may be observed, that palæontologists, like Mr. Darwin and Sir Charles Lyell, cannot, without gross inconsistency, repudiate the doctrine of Final Causes; for in so doing, they deny the justice of the very inference, or assumption, call it which you may, on which their whole science is based. Geologists have no better reason, and no reason of a different kind, for affirming that *fossil* animals and plants did once, millions of years ago, exist as *living* animals and plants, than philosophers and theolo-

gians have for declaring that the animal and vegetable kingdoms — i. e. God's works — show purpose and intention just as clearly as man's works do. No direct proof is possible in either case. The only argument is from analogy and an appeal to common sense. The sceptic may defy Mr. Darwin to prove *directly*, that the Silurian fossils did not exist primarily, *ab origine*, in the rock where we now find them, — composed of stone, as they now are. For, take the doctrine of Democritus and Epicurus, which, as already intimated, is the progenitor of this Development Theory. If the mere fortuitous concourse of atoms, in the lapse of a past eternity, can have formed a *living* tree, fish, or elephant, then, we say, that same rudderless and purposeless crowd of primeval atoms, in the lapse of a past eternity, can have formed, what is much easier, a fossil tree, fish, or elephant, *as fossils.*

Yet Mr. Darwin assumes the previous existence of these fossils in a living state, as a means of building up a theory which shall enable him to assert that "a structure even as perfect as the eye of an eagle might be formed by natural selection;" — that is, without any special design or intention to create an organ of vision. He admits that "it is scarcely possible to avoid comparing the eye to a telescope. We know that this instrument has been perfected by the long-continued efforts of the highest human intellects; and we naturally infer that the eye has been formed by a somewhat analogous process." But he asks, "May not this inference be presumptuous? Have we any right to assume that the Creator works by intellectual powers like those of man?" (p. 169.) But this is not the question. There is just as much "presumption" in assuming to determine that the Creator *ought not* to work in a given manner, or through certain "intellectual powers," as in taking it for granted that he *would* or *must* employ such means. In either case, this is assuming to set bounds to Omnipotence, and to prescribe how Infinite Wisdom ought, or ought not, to act. Our only business, as students of natural science, is to follow the evidence wherever it may lead us, and to be consistent in the inferences which we draw from it, leaving it to philosophers and theologians to reconcile, if they can, our conclusions with their preconceived ideas of what is becoming to the Creator. If they cannot reconcile them, so much the worse for their preconceived ideas. Our only question is, Whether it is consistent to infer, from a general analogy of structure with living forms at the present day, that certain fossilized skeletons were living organisms millions of years ago, though we confidently deny, in spite of the far more striking analogy between an eagle's eye and a telescope, that an intelligence presided over the formation of the one similar to that which we know to have concurred in the production of the other? Can we justly infer life from a general analogy of structure, while we refuse to infer intelligence from

a far more obvious analogy in the adaptation of means to ends? Mr. Darwin and Professor Baden Powell answer this question in the affirmative; and it is for them to defend their consistency as they may.

The purpose of the Development Theory, in any of its forms, is to exclude the necessity of believing in any special creative act, or any exertion of intelligence and will, and to refer all physical phenomena, the first appearance of new and distinct races included, to the continuous and uninterrupted action of what are called secondary causes or natural laws. In pursuance of this purpose, even the primitive act of creation, by which the universe was first evolved out of nothingness or out of a chaotic mass, is either denied, or, what is the same thing, is removed to an infinite distance. An *absolute beginning*, either of the universe, or of any Species of animal or vegetable life in the universe, is, on this Theory, an impossible or inadmissible conception. Alluding to the opponents of this doctrine, Mr. Darwin observes (p. 418), "These authors seem no more startled at a miraculous act of creation than at an ordinary birth. But do they really believe that, at innumerable periods in the earth's history, certain elemental atoms have been commanded suddenly to flash into living tissues?" And Professor Powell still more distinctly remarks, "that strict science offers no evidence of the *commencement* of the existing order of the universe. It exhibits, indeed, a wonderful succession of *changes*, but however far back continued, and of however vast extent, and almost inconceivable modes of operation, still only *changes;* occuring in recondite *order*, however little as yet disclosed, and in obedience to physical laws and causes, however as yet obscure and hidden from us. Yet in all this there is no *beginning* properly so called: no commencement of existence when nothing existed before: no *creation* in the sense of origination out of non-existence, or formation out of nothing. Even without referring to that metaphysical *conception*, or more properly metaphysical *contradiction*, to imagine anything which can be strictly called a *beginning*, or first formation, or endowment of matter with new attributes, or in whatever other form of expression we may choose to convey any such idea, *is altogether beyond the domain of science*, as it is an idea beyond the province of human intelligence." *

Still it might be maintained that, although science gives us no glimpse of a Creator, it does point to an Architect of the universe, in so far as it discovers and analyzes the innumerable and marvellous adaptations of means to ends by which this earth is rendered a fitting and convenient habitation for all the tribes that tenant it, and by which

* Rev. Baden Powell's "Order of Nature," (London, Longmans, 1859,) pp. 250, 251. In this quotation the words are italicized as in the original.

the organization of each plant and animal is nicely adjusted to the place which it occupies, and the work which it has to perform. To rebut this conclusion, Mr. Darwin brings forward his improvement of the transmutation theory, in which, as already remarked, the office of Natural Selection is to explain and account for all natural adaptations and adjustments, even the nicest and most complex, without any necessity of supposing that they were intentional or designed, and consequently without any need of referring them to the action of an all-wise Architect.

A careless thinker might yet argue, that Natural Selection itself is only an agent of the Deity, or a law established by Him for the very purpose of effecting the adaptations which are ascribed to it, and which would therefore still be properly regarded as the work of Him by whose will and instrument they were fashioned. But such an argument would betray only confusion of thought. For Natural Selection is neither a created thing, nor a cause, nor a law dependent on the volition of a lawgiver; but it is an abstraction and a generalization. It is not Natural Selection that kills out one or more Species and preserves others; but climate, food, space, enemies, — or the want of them, — these do the work of killing or preserving. God no more created or enacted the law of Natural Selection, than he created or enacted the Binomial Theorem. The Binomial Theorem is the necessary result of the necessary relations of numbers, and even Omnipotence could not abrogate it. Just so, Natural Selection is the inevitable result of the relations of animals to their conditions of existence; or rather, it is a general expression for these relations themselves; and thus Omnipotence could not abrogate it. Change the climate, food, space, enemies, &c., and Natural Selection would still act, but would kill where it now preserves, and preserve where it now kills. Thus, the results of the Theory are necessary or fatalistic; they blot God out of creation everywhere.

Moreover, in regard to the peculiarities, or Individual Variations, on which the Theory is based, and on which this principle of selection is to operate, there is an equal exclusion of intelligence and will, and even of law and order. As already explained, these peculiarities are the exceptions and monstrosities, — the phenomena which least of all admit of being reduced to law, or referred to the action of any uniform cause. These aimless and exceptional *lusus naturæ*, as they appear to most observers, form the chaos or rude matter of the Development Theory, on which the principle of Natural Selection, like the *deus ex machina*, is to operate, and evolve order out of confusion and complex adaptations out of accident. In fact, this principle would have nothing to do, — it would not be *selection*, — if the Individual Variations were not multiplied at random, and were not purposeless in character. The essence of the hypothesis is, that

"there is a power always intently watching each slight *accidental* alteration," (p. 169,) and finding a use or fitness where none was intended; just as a savage, wandering on a sea-beach, may, after long search, find a stone which has a rude semblance of a chisel or an axe, and use it as such. Hence Mr. Darwin speaks consistently (p. 79) of "giving *a better chance* of profitable Variations occurring; and unless profitable Variations do occur, Natural Selection can do nothing." But they will occur, for "Variation will cause the slight alterations, generation will *multiply them almost infinitely*, and Natural Selection will pick out with unerring skill each improvement," (p. 169,) separating it from countless others which are not improvements, but, as useless or injurious, are to be eliminated. "*Mere chance*, as we may call it, might cause one variety to differ in some character from its parents." (p. 104.) True, it is afterwards explained that *chance*, as here used, does not negative a cause. No one supposed that it did; but it does negative any purpose or intelligence in that cause; and Mr. Darwin intimates nothing to the contrary.

There can be no mistake as to the character of such a scheme of cosmogony as this. Creation denied, or pushed back to an infinite distance, and a blind or fatalistic principle watching over a chaos of unmeaning and purposeless things, and slowly eliciting from them, during an eternity, all the order and fitness which now characterize the organized world.

"It cannot be objected that there has not been time sufficient for *any amount* of organic change; for the lapse of time has been so great as to be utterly inappreciable by the human intellect." (p. 402.) Having cited the speculations of the "uniformitarian" geologists upon the long roll of ages, "the millions on millions of years" needed for the explanation of geological phenomena, according to their mode of reading them, it seems a trifling matter for him to ask us to admit, that ages of equal or even greater length may have elapsed, of which we have no record in the rocks; — that, besides the eternity of which we have some sort of geologic evidence, we should acknowledge the probable lapse of another eternity that has left no legible traces behind it, but which happens to be necessary for the purposes of his theory. "Consequently," he says, "if my theory be true, it is indisputable that, before the lowest Silurian stratum was deposited, long periods elapsed, as long as, or probably far longer than, the whole interval from the Silurian age to the present day; and that during these vast, yet quite unknown, periods of time, the world swarmed with living creatures." (p. 268.) "At a period immeasurably antecedent to the Silurian epoch, continents *may* have existed where oceans are now spread out; and clear and open oceans *may* have existed where our continents now stand." (p. 270.)

Such speculations as these appear to be rather exercises of fancy than sober inferences of science. A mere hypothesis of indefinite Cumulative Variation, resting upon analogy, in the absence of all direct proof, must be allowed also to *create its own evidence* of the inconceivable lapse of time requisite for its development, instead of drawing that evidence from distinct and independent sources.

Professor Powell, in his advocacy of the Development Theory, argues at length against the doctrine of Final Causes; but there is only one sentence in Mr. Darwin's volume from which we can infer the nature of his objections to the same doctrine. Speaking of the facts included under the general name of Morphology, he says, "Nothing can be more hopeless than to attempt to explain this similarity of pattern in members of the same class, by utility or the doctrine of Final Causes." Admitting for the moment the correctness of this assertion, what does it amount to? Surely it will not be maintained, that because Final Causes cannot be *discovered everywhere*, therefore they do not *exist anywhere.* No one will contend, that because we cannot see the use of the rudimentary mammæ in the male, *therefore* the corresponding organs in the female are not adapted to the suckling of her young. As well might it be argued that the rain does no good in moistening the parched earth, because other rain-drops are seemingly wasted by falling into the sea. To the reflecting theist, the general similarity of structure declares the unity of the Creator, without contradicting the lessons taught by special adaptations respecting His benevolence and forethought. To borrow Mr. Darwin's own example: — "What can be more curious," he asks, "than that the hand of a man formed for grasping, that of a mole for digging, the leg of a horse, the paddle of the porpoise, and the wing of the bat, should all be constructed on the same pattern, and should include the same bones, in the same relative position?" (p. 377.) Of course, by "the same" pattern, "the same" bones, and "the same" relative position, Mr. Darwin means a *similar* pattern, *similar* bones, position, &c.; that is, that the pattern, bones, and position are alike in part, and different in part. Granted, then, that the doctrine of Final Causes will not explain the likeness; will that of Morphology explain the difference? The typical anterior limb is modified in many different ways, so as to become adapted to the wants of animals with different habits; it becomes a hand for man, a shovel for a mole, a paddle for a porpoise, and a wing for a bat. The similarities in the pattern or groundwork are referred to one principle in science, Morphology; the peculiarities in each special adaptation, to another principle, that of Final Causes. Both the like and the unlike are constituent parts of one structure; they are referred respectively to different, but not contradictory principles; and since neither of these principles is competent for the explanation of the

whole work, we see not why one of them should be accepted to the rejection of the other. Guided by the doctrine of Homologies, the comparative anatomist searches for corresponding parts in different animals; guided by that of Final Causes, whenever he finds a marked peculiarity in one part, he suspects there is a special use or function to be subserved by it; and by persevering in the search, he usually finds out what this use is. Thus, Harvey found that the valves in the veins and arteries opened in opposite directions; and assuming that this difference could not be without a use or purpose, he discovered the circulation of the blood. Homologies may be the better guide to systems of classification of parts and members, though naturalists are not agreed upon this point. But the principle of Final Causes more frequently leads to discoveries in physiology, which science, indeed, has been built up almost exclusively by its aid.

The theist believes, it is true, that a Creator of infinite wisdom and benevolence has made nothing in vain; that there is a use for everything, and a use which it was intended to serve. But he cannot assert that he has discovered this use and fathomed this intention in every instance, without assuming that he possesses infinite wisdom himself. And the naturalist who, because he cannot discover the use, affirms that it does not exist, is guilty of similar presumptuous folly. Looking at the works of finite intelligence, indeed, we find that a purpose is seldom unaccompanied by a want of purpose; that chance appears, so to speak, as the *residuum* of design. Thus, we often throw a stone, not intending to hit anything with it, but only to toss it out of the way. The throwing was intentional, the hitting was accidental. Every act is attended with several immediate results; and as all of them are not necessarily in view of the agent at the time, those which do not enter distinctly into his purpose are ascribed to chance. They are caused by him, but not intended by him. A mechanic cannot fashion a machine, an artist cannot chisel out a statue, without leaving behind him a heap of chips, dust, and refuse matter. A chip is struck off at every blow; but neither its shape, nor the position in which it falls, is designed by the artisan, who is thinking only of the work from which he has pared it away. But because we cannot discern either use or purpose in that heap of refuse matter, we are not to conclude that the finished machine or statue by the side of it is destitute of both. Absence of purpose, then, may often be affirmed of the results of human labor; but it can never be declared with certainty of the works of creation. Infinite wisdom leaves no *residuum* for chance, and that which is not subservient to one purpose may have been intended for another. If not useful to the organism in which it is found, it may answer some higher object in the economy of creation. It may be a means, and intended as such,

for the higher education of man, or for the attainment of moral as well as physical ends.

The same remark is applicable for the explanation of another difficulty mentioned by Mr. Darwin. He objects that "all the contrivances in nature are not, as far as we can judge, absolutely perfect, and some of them are even abhorrent to our ideas of fitness." (p. 409.) And he cites, as instances, the sting of the bee causing the bee's own death, the hatred of the queen-bee for her own fertile daughters, and the ichneumonidæ that feed within the bodies of live caterpillars. He might as well have adduced the existence of all the *Carnivora*, man himself included, together with the frequent occurrence of pain and death. We are not wont to hear the old problem respecting the existence of evil alleged as an argument in favor of a novel speculation in zoölogy. But when certain arrangements are declared to be imperfect or unfit, we have a right to ask by what standard they have been tried. Perfect for what end? Fit for what purpose? If the only conceivable intention were to guard the life of every individual bee, perhaps a more effectual means might have been discovered than that of furnishing it with any sting at all. Many insects exist in vast numbers that have no such weapon. Human knowledge, also, is so far from comprehending the whole plan of creation, and all the purposes of its Author, that it seems reasonable to admit the evidences of design where they are so obvious that they cannot be overlooked, and to refer all other cases to our limited means of observation and the imperfection of our faculties. The difficulty, moreover, may be retorted upon the advocates of the Development Theory. As Natural Selection preserves only the useful, and kills out all worthless and noxious Variations, how comes it to have left, in a weapon otherwise so perfect, this one fatal defect, that it cannot be once used without causing the death of its owner?

The necessities of his theory compel Mr. Darwin to maintain that the most complex *instincts*, as well as the nicest adaptations of structure, can have been produced only "by the slow and gradual accumulation of numerous slight, yet profitable, variations." But he has seemingly failed to observe that instinct and structure are nicely correlated to each other, and must be so correlated, or the animal would perish. Consequently, the *variations* of structure and instinct must have been simultaneous and accurately adjusted to each other, as a modification in the one, without an immediate corresponding change in the other, would have been fatal. He has also failed to remember, that the highest and most complex instincts are generally found in very low structural forms; for instance, among bees, ants, and spiders, rather than among vertebrates, and in birds more than in mammals. The progress of improvement, then, in the two cases, cannot have been always by equal and corresponding steps; for the development

of instinct stopped long ago, while the organic structure has advanced from a spider's up to a man's. It is not a law of nature, then, that a change of the organism should always be accompanied by a change of instinct nicely adapted to it; consequently, the Development Theory can offer no explanation of the fact, that the organism must always have harmonized precisely with the instinct, while the latter was slowly perfected by innumerable variations. It is impossible that so nice a correspondence, maintained between the two during countless independent changes of each, should have been purely accidental or unintentional.*

Those who deny that there has been any special act of creation since living forms first appeared upon the earth, are bound, of course, to account for the origin of the human species, just as much as for that of the lowest insect. Mr. Darwin confesses as much when he says that, after the general reception of his system, "psychology will be based on a new foundation, that of the necessary acquirement of each mental power and capacity by gradation. Light will be thrown upon the origin of man and his history." (p. 423.) He is bound, therefore, to find the means of bridging over, by innumerable slight gradations, the immense gap which now separates man from the animals most nearly allied to him, — a gap not only between the two structural forms, which, however dissimilar, may still be affirmed to be of the same kind, but between reason and instinct, where nearly all psychologists are agreed that the difference is in kind, and not merely in degree. As Sir C. Lyell remarks, "the sudden passage from an irrational to a rational animal is a phenomenon of a distinct kind from the passage from the more simple to the more perfect forms of animal organization and instinct." †

Here an obvious objection occurs, founded upon the comparative shortness of the time during which man has been a resident upon the earth. "Man," says Lyell, "must be regarded by the geologist as a creature of yesterday, not merely in reference to the past history of the organic world, but also in relation to that particular state of the animate creation of which he forms a part." ‡ Even the questionable evidence recently obtained from the discovery of flint knives and arrow-heads in localities where their presence is difficult to be accounted for, does not enable us to ascribe to the human race a higher antiquity than that of the later post-Tertiary formations. Then the interval of time, within which far the broadest chasm which we have to contem-

* Here, and elsewhere in this Memoir, a few remarks have been repeated, in an abridged form, which were first published in an article contributed by me to the North American Review for April, 1860.

† Lyell's Principles of Geology, Am. ed. 1853, p. 148.

‡ Ibid., p. 182.

plate in zoölogy is to be filled up by innumerable transitional forms, is certainly the shortest which geology has revealed. As the most recent, also, it is one the history of which is most perfectly known. During this period, certainly, it is in the highest degree improbable that innumerable species should have lived and died out without leaving behind them any trace of their existence. The few fossil monkeys that have been discovered are not so near approximations to the human form as several anthropoid species that are now living. How, then, can man have been developed during this short epoch, by the indefinitely slow process of Cumulative Variation and Natural Selection, out of a monkey? and where are the countless extinct types that should mark the steps of his progress? How many varieties must have existed as strict transitional forms to fill up this broad gap, — to say nothing of the greater, infinitely greater number of variations which were not improvements, but which must also have appeared and died out under a liability to change having no direction or purpose but that of chance! Geology can find no traces of them. The latest chapter of the Stone Book, which is far the best preserved, and which ought to be nearly filled with variations upon this single theme, does not record a single form intermediate between man and the chimpanzee.

Moreover, if reason has been developed out of instinct, these innumerable forms between the Quadrumana and the Bimana must have had an enormous advantage in the Struggle for Life over their less intelligent competitors, so that the total disappearance of their remains becomes still more inexplicable. Bones of their brute contemporaries, hyenas, bears, rhinoceroses, elephants, and even a few monkeys, are found by the cart-load in many localities. But a crowd of half-reasoning animals, developed out of orangs, chimpanzees, or gorillas, furnished with tools and weapons, and capable, if we may judge from their other semi-human attributes, of adapting themselves to a wide range of circumstances, and which ought, consequently, to have multiplied without stint, because they were sure to triumph over their brute rivals in every contest for the ground or for food, have yet perished so entirely, that not a vestige of their skeletons has been anywhere discovered.

The doctrine that reason has been developed out of instinct, depends entirely upon the assumption that these two faculties differ from each other in degree only, and not in kind. If psychology is to be placed upon a new foundation, as Mr. Darwin assures us, "that of the necessary acquirement of each mental power and capacity *by gradation*," there must be a conceivable transition from instinct to reason through a number of steps, every one of which must be an improvement. Here we are at once met by the difficulty, that the power of instinct, in many cases, quite transcends that of reason; if

it differs from human intelligence in degree only, it is in these instances undoubtedly the superior. Man may go to school to the spider, the ant, the wasp, and the bee, but he can never equal his teacher. Compare the habitations, the nets, and other structures of these insects, with those of the lower savages, such as the Hottentots and the native Australians, and say which are the more artistic and the more nicely adapted to their purposes; especially when we add the necessary qualification, that the insect works without any tools except those which are parts of its own body. Man has had bitter experience enough in the matters of government and social organization, and the wisdom of thirty centuries has been exhausted in pondering upon the several problems of social philosophy; but he is still unable to form a society which, in point of orderly arrangement, harmony, and effective co-operation for the general good, even approaches the excellence of a hive of bees. Since the latest form of the Development Theory allows no variation to be preserved and perpetuated, except it be an improvement, since Natural Selection inevitably kills out every change except it be for the better, how comes it that human reason has deteriorated in all these respects ever since it began to be built up from the narrow foundations of an insect's instinct? It is no answer to say, that reason is still immeasurably the superior in the number, comprehensiveness, and ductility of its endowments, and especially in those powers of adaptation and invention by which it is fitted for all emergencies. The question still remains, Why, if it has improved in so many respects, has it deteriorated in any?

But the difficulty of accounting for the transmutation of instinct into reason becomes vastly greater, when it is remembered that a leading characteristic of the former is, that it admits of no variation whatever, — that, as far as human observation has extended, it is absolutely unchangeable, both in the individual and in the race. Instinct, it is true, has a certain degree of *pliability*, enough to provide for the ordinary and perpetually recurrent emergencies of the special occasion for which it was created. Otherwise, the faculty would very seldom answer its purpose, or be competent for its destined work. Thus, the spider which always fashions a circular web, as it can seldom or never find a nearly circular opening in which to suspend it, must be able to change the length and direction of the suspending threads, so as to hang the structure easily and economically in an opening of any shape, triangular, quadrangular, or altogether irregular, such as it may best find. But the absolute invariability of the instinct appears even here, in the fact that the web of this spider is always circular and curiously symmetrical, though so much contrivance is thereby needed to suspend it with proper stiffness; and though a triangular web, such as is always spun by an allied species, would remove all difficulty and answer every purpose. The range of this pliability,

also, is always confined within very narrow limits. The instinct is invariably pliable to the same extent, and that a very limited one. Bees and wasps build cells very nearly on the same pattern, which is curiously elaborate and symmetrical; they even change this pattern a little, so as to fit together the cells of different sizes which they need, or to hang securely the topmost or innermost row of cells to the top or side of their habitation; always returning, however, to the typical form of the cell as soon as possible. Bees build invariably with wax, wasps invariably with a paper-like substance, though an interchange of these materials would often be convenient, and a capacity of changing the material on an emergency would certainly conduce to the animal's preservation.

A true *variation*, such as this Theory requires, would be the manifestation by an individual in the wild state, or undomesticated, of some feat, quality, or degree of instinct, however slight, totally unlike anything that had been manifested by its fellows. Of such variation the observations of naturalists have not afforded us a single instance. The architecture and internal economy of a beehive or a wasps' nest, so far as known, marvellously complex and elaborate as they are, have not varied by a hair's breadth since the days of Aristotle. Bees have been carefully watched by man for over two thousand years; they have been carried by him to a vast number of localities beyond those originally inhabited by this insect. The whole continent of America has been populated by the ordinary hive-bee from Europe. Thus the experiment, whether change of circumstances might not possibly induce variation, may be said to have been fairly tried. There are from 15,000 to 20,000 bees in every healthy hive; and the number of their hives, taking all parts of the world together, almost defies calculation. This enormous stock of them has to be renewed at short intervals, as the bee's life does not usually exceed a single year. And yet the typical bee cell, with all its marvellous symmetry and complexity, finished with the precision of a 100,000th part of an inch, has not changed the length of one of its lines since it first excited the astonishment of man. With this known amount of invariability, how great is the time that would be requisite for developing the instinct of a bee into human reason?

But here it is necessary that instinct should be sharply distinguished from some of the other powers with which it is generally accompanied. No one denies that the brutes have certain mental endowments in common with men. They have appetites, propensities, desires, affections, memory, simple imagination or the power of reproducing the sensible past in mental pictures, and even judgment of the simple or intuitive kind. They compare and judge, as when the dog or cat decides correctly what height or breadth it can safely jump, or how large an orifice must be to admit the pas-

sage of its body. But they cannot judge by inference, or through the intervention of a third term; that is, they cannot reason. They cannot generalize their experience, and thus form premises from which many conclusions can be drawn. Their judgment, as intuitive, is always of the particular case presented to their senses, and never as an inference from a general rule. The only end which they can pursue, or even contemplate, apart from the guidance of instinct, is particular and immediate, dictated by the appetite or impulse of the moment. Hence, they cannot combine means for the attainment of a future or general object, and thus their modes of operation are never altered or improved.

Instinct is the power given to compensate for these deficiencies, which would otherwise be fatal to life or destructive of the species. It appears as a substitute for reason, not as a lower degree of it; it answers the same purpose, but by totally different means. Instinct is the performance by an animal of some act (the construction of a nest or cell, or the laying of a stratagem for catching its prey) which man could not perform without intelligence or reason, properly so called; that is, without experience or instruction, the observation of effects, the induction of a rule or law from them, and the consequent future choice and adaptation of means to ends. This act the animal demonstrably performs without either experience or instruction, but just as blindly as the bird tucks its head under its wing when going to sleep, without knowing why. The act does tend to some useful end, though the animal knows not of it. Foresight it has none, unless it be the foresight of a god rather than a man; for human prescience is nothing but the reflection of the past upon the mirror of the future. Neither reason nor instinct supplies an object of endeavor, but only points out the means of attainment, the former relying exclusively upon experience, the latter appearing, at least to human observation, to be guided by inspiration. A blind propensity induces the duckling to take to water; instinct teaches it how to swim. The migratory bird is urged by a vague impulse at the proper season to change its country; instinct turns its flight in the right direction. Surely it would be no improvement in either of these cases, no development of a higher faculty out of a lower one of the same kind, if reason were substituted for instinct, the tardy and uncertain teachings of experience for the instantaneous and unerring guidance of inspiration. That power or faculty, call it what we may, bears not the remotest semblance of human reason which teaches a wasp, born only after the death of its parents, to store up food of a kind which it never uses for itself, for the use of its young which it is never to see. Neither a propensity nor an appetite is an instinct, though all three are equally blind. For

man also has both propensities and appetites which need not the promptings of intellect, but are awakened before reason is born in him. Tastes, smells, and sounds are pleasant or odious to him as a matter of original constitution, and not because his reason tells him that these ought to be sought, and those to be avoided.

This is not an arbitrary definition or limitation of the meaning of the word *instinct;* for if, as Mr. Darwin says, human reason is to be developed out of the brute's endowments, be these what they may, — if man is the son of a monkey, and the grandson of a horse, and the remote descendant of an oyster, — then reason must grow out of something which has at least some characteristic of reason, or which does the work of reason; and not from something which even now, in man, has no resemblance to intellect properly so called, and no dependence upon it, and which appears fully even in an idiot. Tell me that reason has been developed out of instinct *as it has now been defined*, and at least I know what you mean; but to say that it has been evolved from an appetite or a propensity, is as incomprehensible as to allege that an idea has been developed out of a football. No conceivable variation of a football will approximate it to reason. Mr. Darwin's supposed cases of incipient, altered, or lost instincts are, at best, only instances of the development or disappearance of blind impulses or appetites, which relate only to the selection of ends to be obtained, and not to devising new means, or improving old ones, of obtaining them. He has not adduced one case of the variation of instinct properly so called.

Any form of the Development Theory rests ultimately upon the assumption, that the origin of species by a direct act of creation is inconceivable, or at best grossly improbable. Mr. Darwin, as already mentioned, speaks with wonder of those who are "no more startled at a miraculous act of creation than at an ordinary birth." And Professor Parsons, in a communication upon the same subject to this Academy, declared that, whatever difficulties might impede the reception of the transmutation hypothesis, "I should accept them all unhesitatingly, rather than the notion that the first horse, or dog, or eagle, or whale flashed into being out of nothingness, or out of a mass of inorganic elements which had been drawn together in due proportion for that purpose."

In opposition to this view, it is here maintained that a direct act of creation is no more inconceivable, and not inconceivable in any other sense, than an ordinary birth. It excites more wonder, it is true; but only because it is less frequent, or because it is believed to take place more abruptly. A new individual — a new being — is the result in either case; but to assert that the beginning of this new existence is more explicable

by ordinary generation than by direct creation, is equivalent to saying (if the folly and irreverence of the expression may be pardoned), "that a horse should create a horse is conceivable; but that God should create a horse is inconceivable." The beginning of all life is in a nucleated cell of microscopic size. The original formation of such a cell, and the subsequent enlargement or rather multiplication of it by the epigenesis of other similar cells, are distinct acts of creation properly so called, whether preceded or not by a generative union of the parents. That the generative act should be ordinarily followed by the vivification of such a cell, is a law of nature, which, like other natural laws, does not explain the phenomena, nor throw any light upon them, but merely describes and classifies them; and if naturalists were once led to believe the union of two sexes to be a necessary or invariable antecedent of the vivification, the discovered fact of parthenogenesis has convinced them of their mistake. The first appearance, then, of this living cell, is an indubitable case of an organized individual at once "flashed into being," not indeed "out of nothingness," but "out of a mass of inorganic elements drawn together in due proportion for that purpose"; and special or miraculous creation, which appears so incredible or inconceivable to the advocates of the Development Theory, is in fact constantly going on all around us. Whether we call it creation or ordinary generation, the process — the mode in which inorganic particles are suddenly bound together into an organic living whole — is wholly inexplicable. Science throws down her microscope before the process in despair. But inexplicable as it is, we are not able to deny that it is a law of nature which is perpetually verified before us. We cannot tell *how* a blade of grass grows; but we do not therefore affirm that it does not grow.

No one who understands the case will assert, that either the scale on which the phenomenon takes place, or the frequency of its repetition, or the length of time within which it is completed, is a radically distinguishing circumstance which prevents us from identifying ordinary reproduction with direct creation. Frequent repetition, indeed, wears out wonder; but it does not make the process one whit more explicable than if it occurred only once in a millennium. One microscopic germ may be slowly developed into a giant pine, which may reckon its years by centuries; and another may give birth to an insect that completes its whole cycle of being in a single season. But science knows as little of the process in the one case as in the other, and justly classes them both under the same name of generative development. "If an animal or a vegetable," says Dugald Stewart, "were brought into being before our eyes *in an instant of time*, the event would not be in itself more wonderful than their *slow growth* to matu-

rity from an embryo or from a seed. But on the former supposition, there is no man who would not perceive and acknowledge the immediate agency of an intelligent cause; whereas, according to the actual order of things, the effect steals so insensibly on the observation, that it excites little or no curiosity, excepting in those who possess a sufficient degree of reflection to contrast the present state of the objects around them with their first origin, and with the progressive stages of their existence."

V.

On the Secular Variations and Mutual Relations of the Orbits of the Asteroids.

By SIMON NEWCOMB.

(*Communicated April* 24, 1860.)

When we consider the number of members of which the group of asteroids is composed, and the narrow limits within which they are included, it is impossible to avoid the conclusion that their proximity is the result of a common element in the determining reasons which fixed the respective positions of their several orbits, which common element has some special relation to that portion of space in which the orbits of the asteroids are found which it has not to other portions of space.

The object of the present paper is to examine those circumstances of the forms, positions, variations, and general relations of the asteroid orbits which may serve as a test, complete or imperfect, of any hypothesis which may be made respecting the cause from which they originated, or the reason why they are in a group by themselves. It may not, however, be out of place to begin with some general considerations respecting these hypotheses, and the nature of the methods by which they may be tested. Every *a posteriori* test is founded on the supposition that the hypothesis to be tested necessarily or probably implies that certain conditions must be fulfilled by the asteroids or their orbits. The tests consist in observing whether these conditions are fulfilled. The conditions may be divided into two general classes, — those which are rigorous and necessary, and those which are merely probable. The former class consists of those which follow immediately and necessarily from the hypothesis itself; the latter, of those which are deducible from it by the principle of random distribution. The nature of the latter conditions will be clearly seen from the examples which will be given of their deduction from hypotheses.

Two hypotheses worthy of consideration have been promulgated respecting the

origin of the asteroids; one, that they are the fragments of a single planet, which was shattered by the operation of some unknown cause; another, that they were formed by the breaking up of a revolving ring of nebulous matter.

The first of these is the celebrated hypothesis of Olbers. It has the advantage of accounting for the phenomena, considered in their more salient aspects, in a very remarkable manner. The normal solar system is still the solar system as we should expect it to be in the absence of any knowledge of the planet or planets revolving between Jupiter and Saturn. The phenomenon (abnormal on this hypothesis) of the place of a single large planet being filled by a collection of small ones of varying brilliancy, large inclinations and eccentricities, and slightly different mean distances, is precisely what might be expected as the result of a force which should break the planet into fragments, each very small in comparison with the original planet. But we shall see hereafter that when we carry the results of this hypothesis to numerical exactness, the observed phenomena are very far from agreeing with these results. Moreover, it is difficult, perhaps impossible, to imagine how any known natural cause, or combination of causes, should produce such a result as the shattering of a planet. But since the limits of our knowledge are not necessarily the limits of possibility, this objection is not fatal, and it is difficult to say what weight ought to be assigned to it.

The second hypothesis, that the asteroids were formed by the breaking up of a ring of nebulous matter, is not at all improbable if the nebular hypothesis is true, but it is subjected to most or all the uncertainties of that hypothesis. The ring must have been considerably inclined to the plane of the ecliptic, or none of its fragments could have fallen into orbits much inclined to that plane; and it could not have revolved in its own plane, else all the fragments would have had nearly the same inclination to the invariable plane of the solar system; and it must have been somewhat eccentric, else all the fragments would have had about the same mean distance. Now it is remarkable that the two last circumstances would cause a tendency in the ring to break into fragments, while a circular ring, revolving in its own plane, would have no such tendency. We should then expect, in case a ring should break up, that its fragments would present some at least of the phenomena presented by the asteroids. But the hypothesis is not equally susceptible with that of Olbers of *a posteriori* tests.

To apply rigorous tests to either of the above-mentioned hypotheses, we need rigorous expressions in terms of the time for the values of the eccentricity, inclination, longitude of perihelion, and longitude of node, of each asteroid used in applying the test. For the probable tests we need the mean and the limiting values of the same elements, and to obtain these the same expressions are necessary.

The subject may be arranged under the following heads: —

§ 1. Computation of the rigorous expressions in terms of the time of the elements of the asteroids.

§ 2. Of the possibility that the orbits of all the asteroids once intersected in a common point.

§ 3. Have the elements of the asteroid orbits ever been materially affected by a resisting medium?

§ 4. Of the relations among the mean distances, eccentricities, and inclinations of the orbits of the asteroids; and between their masses and the velocities with which they must have been projected, if Olbers's hypothesis be true.

§ 5. Of certain observed relations among the asteroids which are the necessary or probable result of known causes, and therefore throw no light on the origin of the asteroids.

§ 1. *Computation of the Rigorous Expressions in Terms of the Time of the Elements of certain of the Asteroid Orbits, or of the Secular Variations of those Elements.*

To obtain the required expressions, we shall start from the expressions given by Laplace in the *Mécanique Céleste*, Liv. II. §§ 55 & 59.

$$\left.\begin{aligned}\frac{dh}{dt} &= \{(0,1)+(0,2)+(0,3)+\&c.\}\, l - [0,1]\, l' - [0,2]\, l'' - \&c.\\ \frac{dl}{dt} &= -\{(0,1)+(0,2)+(0,3)+\&c.\}\, h + [0,1]\, h' + [0,2]\, h'' + \&c.\end{aligned}\right\} \quad (1)$$

$$\left.\begin{aligned}\frac{dp}{dt} &= -\{(0,1)+(0,2)+\&c.\}\, q + (0,1)\, q' + (0,2)\, q'' + \&c.\\ \frac{dq}{dt} &= \{(0,1)+(0,2)+\&c.\}\, p - (0,1)\, q' - (0,2)\, q'' - \&c.\end{aligned}\right\} \quad (2)$$

where

$$h = e \sin \pi, \qquad l = e \cos \pi,$$
$$p = i \sin \Omega, \qquad q = i \cos \Omega.$$

The unaccented symbols relate to the disturbed planet, which, in our present investigation, is supposed to be an asteroid; the accented quantities relate to the disturbing planets. The expressions given by Laplace for the quantities (0,1) and [0,1] are

$$(0,1) = -\frac{3\, m'\, n\, a^2\, b^{(1)}_{-\frac{1}{2}}}{4\,(1-a^2)^2};$$

$$[0,1] = -\frac{3\, a\, m'\, n\, \{(1+a^2)\, b^{(1)}_{-\frac{1}{2}} + \frac{1}{2}\, a\, b^{(0)}_{-\frac{1}{2}}\}}{2\,(1-a^2)^2};$$

a representing the ratio of the mean distances of the disturbing planet and the asteroid, and the other symbols being used in their usual signification.

These equations may be so simplified as to materially facilitate the computation of the required quantities. The following equations are given by Laplace in § 49.

$$\frac{b_{-\frac{1}{2}}^{(0)}}{(1-\alpha^2)^2} = b_{\frac{3}{2}}^{(0)}; \qquad \frac{-3\,b_{-\frac{1}{2}}^{(1)}}{(1-\alpha^2)^2} = b_{\frac{3}{2}}^{(1)};$$

$$b_s^{(i)} = \frac{(i-1)\,(1+\alpha^2)\,b_s^{(i-1)} - (i+s-2)\,\alpha\,b_s^{(i-2)}}{(i-s)\,\alpha}.$$

By a comparison of these equations with the values of (0.1) and [0.1] given above, the latter reduce to

$$(0,n) = \frac{m^{(n)}\,n}{4}\,\alpha^2\,b_{\frac{3}{2}}^{(1)}; \qquad [0,n] = \frac{m^{(n)}\,n}{4}\,\alpha^2\,b_{\frac{3}{2}}^{(2)}. \qquad (3)$$

With these equations we can obtain the numerical values of $(0,n)$ and $[0,n]$ with great ease, provided that we have tables which give the values of $b_s^{(i)}$ for different values of α, such as those published by Runkle in the Smithsonian Contributions to Knowledge.

To integrate the equations (1) and (2), we shall suppose all the accented quantities, l', l'', h', &c., p', &c., q', &c., given in terms of the time. This is admissible, because we neglect the action of the asteroids on the larger planets, and also on each other; we may, therefore, use the expressions for the elements of the larger planets in functions of the time, which are obtained in neglecting the action of the asteroids. These expressions are of the following form:—

$$\left.\begin{aligned} h' &= N'_0 \sin\,(g\,t+\beta) + N'_1\,\sin\,(g_1\,t+\beta_1) + N'_2\,\sin\,(g_2\,t+\beta_2) + \&c. \\ l' &= N'_0 \cos\,(g\,t+\beta) + N'_1\,\cos\,(g_1\,t+\beta_1) + N'_2\,\cos\,(g_2\,t+\beta_2) + \&c. \\ h'' &= N''_0 \sin\,(g\,t+\beta) + N''_1\,\sin\,(g_1\,t+\beta_1) + \&c. \\ l'' &= N''_0 \sin\,(g\,t+\beta) + N''_1\,\sin\,(g_1\,t+\beta_1) + \&c. \\ &\quad \&c. \qquad\qquad \&c. \end{aligned}\right\} \qquad (4)$$

$$\left.\begin{aligned} p' &= M\sin\gamma + M'_1\,\sin\,(k_1\,t+\gamma_1) + M'_2\sin\,(k_2 t+\gamma_2) + \&c. \\ q' &= M\cos\gamma + M'_1\,\cos\,(k_1\,t+\gamma_1) + M'_2\cos\,(k_2\,t+\gamma_2) + \&c. \\ p'' &= M\sin\gamma + M''_1\,\sin\,(k_1\,t+\gamma_1) + \&c. \\ &\quad \&c. \qquad\qquad \&c. \end{aligned}\right\} \qquad (5)$$

In the second members of these equations, all the symbols, except t, represent known constants. If we substitute the expressions (4) in (1), and put for brevity

$$\left.\begin{aligned} E_0 &= [0,1]\,N'_0 + [0,2]\,N''_0 + [0,3]\,N'''_0 + \&c. \\ E_1 &= [0,1]\,N'_1 + [0,2]\,N''_1 + [0,3]\,N'''_1 + \&c. \\ &\quad \&c. \qquad\qquad \&c. \\ b &= (0,1) + (0,2) + \&c. \end{aligned}\right\} \qquad (6)$$

the equations (1) reduce to

$$\left.\begin{aligned}\frac{dh}{dt} &= \quad b\,l - E_0 \cos(g\,t+\beta) - E_1 \cos(g_1 t + \beta_1) - \ldots \\ \frac{dl}{dt} &= -b\,h + E_0 \sin(g\,t+\beta) + E_1 \sin(g_1 t + \beta_1) + \ldots\end{aligned}\right\} \qquad (7)$$

The integrals of these equations may be expressed in the form

$$\left.\begin{aligned}h &= \frac{E_0}{b-g}\sin(g\,t+\beta) + \frac{E_1}{b-g_1}\sin(g_1 t+\beta_1) + \ldots + A\sin(b\,t+B) \\ l &= \frac{E_0}{b-g}\cos(g\,t+\beta) + \frac{E_1}{b-g_1}\cos(g_1 t+\beta_1) + \ldots + A\cos(b\,t+B)\end{aligned}\right\} \qquad (8)$$

A and B being arbitrary constants, depending on the values of h and l at a given epoch.

The integral values of p and q may be obtained by a similar process. By putting

$$\left.\begin{aligned}I_0 &= (0,1)\,M + (0,2)\,M + (0,3)\,M + \ldots = b\,M \\ I_1 &= (0,1)\,M'_1 + (0,2)\,M''_1 + (0,3)\,M'''_1 + \ldots \\ &\&c. \qquad\qquad \&c.\end{aligned}\right\} \qquad (9)$$

we have from (2) and (5)

$$\left.\begin{aligned}\frac{dp}{dt} &= -b\,q + I_0\cos\gamma + I_1\cos(k_1 t+\gamma) + I_2\cos(k_2 t+\gamma_2) + \ldots \\ \frac{dq}{dt} &= \quad b\,p - I_0\sin\gamma - I_1\sin(k_1 t+\gamma) - I_2\sin(k_2 t+\gamma_2) - \ldots\end{aligned}\right\} \qquad (10)$$

The integrals of these equations are

$$\left.\begin{aligned}p &= M\sin\gamma + \frac{I_1}{b+k_1}\sin(k_1 t+\gamma) + \frac{I_2}{b+k_2}\sin(k_2 t+\gamma_2) + \ldots + K\sin(-b\,t+C) \\ q &= M\cos\gamma + \frac{I_1}{b+k_1}\cos(k_1 t+\gamma_1) + \frac{I_2}{b+k_2}\cos(k_2 t+\gamma_2) + \ldots + K\cos(-b\,t+C)\end{aligned}\right\} \qquad (11)$$

K and C being arbitrary constants, depending on the values of p and q at a given epoch.

To give a clear idea of a geometrical construction of these equations, suppose a sphere described around the sun as a centre, and let the radius of this sphere be taken for unity. Let the point in which the pole of the ecliptic (or other plane of reference) cuts the surface of the sphere be taken as an origin of co-ordinates. From this origin draw on the sphere a radius vector equal to M, and making an angle equal to $\gamma - 90^\circ$ with the axis of x, from which we suppose the longitude to be reckoned. From the end of the first radius vector, draw another equal to $\frac{I_1}{b+k_1}$, and making an angle equal to $\gamma_1 - 90^\circ$ with the axis of x, and so continue through all the terms of the second member of (11). The end of the last radius vector, K, will be on the point in which the pole of the orbit of the asteroid intersects the sphere at the origin of

time. If, now, we suppose the radius vector $\frac{I_1}{b+k_1}$ to move around the end of M with a uniform angular motion equal to k_1, $\frac{I_2}{b+k_2}$ to move around with an angular motion of k_2, and so on to K; the end of K will continually be on the point in which the pole of the orbit of the asteroid intersects the surface of the sphere.

M and γ are the same for all the planets and asteroids; the end of M may therefore be taken as an origin around which the poles of the orbits of all the planets and asteroids move. This point is evidently the mean position of the pole of each separate planet and asteroid during all time,* and the plane of which it is the pole may be regarded as the mean position of the plane of the orbit of each heavenly body during all time. This plane is the invariable plane of maximum areas; as may be seen from the fact that the constant M vanishes when we take that plane as the plane of reference.†

This plane ought, also, to be the probable mean position of the orbits of the several asteroids at any one time, in so far as the positions of the separate orbits are independent of each other, and to the same degree, the nodes on this plane ought to be distributed at random. We shall return to this subject when considering the distribution of the nodes and perihelia in longitude.

In the above investigations and constructions, quantities of the third order with respect to the eccentricities and inclinations have been neglected, and we have therefore made no distinction between the distance from the origin of the poles of the orbits on the surface of the sphere, and of the points in which these poles intersect the tangent plane, or the secant plane which passes through the point, and is parallel to the tangent plane; or between i, $\sin i$, and $\tan i$.

In the above construction, the distance of the final point, or pole of the orbit of the asteroid, from the pole of the ecliptic, will be equal to the inclination, and its longitude increased by 90° will be equal to the longitude of the node. If, then, one of the radii vectores $\frac{I}{b+k}$ . . . . . K is longer than the sum of all the others, it is evident that the amount by which it exceeds that sum will be an inferior limit of the inclination, and that the mean motion of the node will be equal to the coefficient of t in the angle which corresponds to the longest radius vector.

Let us now apply the formulæ given above to the numerical computation of the elements of the asteroids in terms of the time. Many of the required quantities being

* In other words, if we mark on the plane tangent to the sphere, and parallel to the invariable plane, the points in which the pole of the asteroid orbit intersects it at equidistant intervals of time, to infinity, the point of tangency will be the centre of gravity of all these points.

† *Méc. Céleste*, Liv. II. No. 62.

functions of the mean distances only of the asteroids, it will be convenient to tabulate them for different values of that element; and by means of such tables, the equations required can be obtained for any asteroid whatever, of which both the eccentricity and inclination are small, with very little labor. In the computation I use the following values of the masses of the disturbing planets.

Venus $\frac{1}{390000}$, Earth $\frac{1}{354936}$, Mars $\frac{1}{2860637}$, Jupiter $\frac{1}{1050}$,
Saturn $\frac{1}{3502}$, Uranus $\frac{1}{21000}$, Neptune $\frac{1}{17000}$.

The direct action of Mercury is neglected, it being entirely insensible.

Making use of these values of the masses, and of the usual values of the mean distances; calling (0,1), [0,1], the coefficients between an asteroid and Venus, (0,2) [0,2], between an asteroid and the Earth, and so on, we have the following values of those coefficients in seconds, the unit of time being 365¼ days.

a	(0,1)	(0,2)	(0,3)	(0,4)	(0,5)	(0,6)	(0,7)
2.2	0.″102	0.″268	0.″184	31.″076	1.″156	0.″022	0.″007
2.4	0.073	0.183	0.104	38.359	1.345	0.025	0.008
2.6	0.053	0.131	0.066	47.372	1.550	0.028	0.009
2.8	0.040	0.096	0.044	58.727	1.775	0.032	0.010
3.0	0.031	0.073	0.032	73.315	2.021	0.036	0.011
3.2	0.025	0.057	0.023	92.495	2.291	0.039	0.012
a	[0,1]	[0,2]	[0,3]	[0,4]	[0,5]	[0,6]	[0,7]
2.2	0.″041	0.″148	0.″148	16.″036	0.″331	0.″003	0.″001
2.4	0.027	0.093	0.078	21.485	0.419	0.004	0.001
2.6	0.018	0.062	0.046	28.587	0.523	0.005	0.001
2.8	0.013	0.042	0.029	37.930	0.644	0.006	0.001
3.0	0.009	0.030	0.019	50.381	0.784	0.007	0.001
3.2	0.007	0.022	0.013	67.277	0.947	0.008	0.002

We next require the numerical values of the quantities represented in (4) and (5) by N and M. These are obtained by the simultaneous integration, for the larger planets, of the systems of equations (1) and (2), a process so laborious, that only three or four astronomers have ever attempted to carry it through. It seems to have been done most completely by Le Verrier, before the discovery of Neptune, as he then gave the differential coefficients of the several quantities with respect to the masses; and he has since taken into account the action of that planet, but has not given these differential coefficients, nor has he considered in what way the action of Neptune might be modified by that of the planets inside of Jupiter. Still, it is quite possible, that the inaccuracies thus introduced are no greater than those which proceed from the neglect of terms of the third order, and we shall therefore use throughout the values given by

Le Verrier in the second volume of his *Annales de l'Observatoire.* They are condensed into the following tables. The quantities omitted are presumed to be insensible. Some of them are known to be so; the remainder are certainly very small, and no data for their computation are given by Le Verrier or any other writer.

n	N_n^{I}	N_n^{II}	N_n^{III}	N_n^{IV}	N_n^{V}	N_n^{VI}
0	+.00048	+.00053	+.0007	+.003057	+.00274	+.031
1	+.01679	+.01661	+.0191	+.042675	+.03334	—.048
2	—.00038	+.00237	+.0152	—.015509	+.04831	—.002
3	+.01689	+.01062	+.0017	—.000020	—.00002	....
4	—.02383	—.01892	—.0033	+.000012	+.00001	....
5	—.01301	+.01178	+.0292	—.000001	—.00001	....
6	+.01534	—.01691	+.0730	—.000001	—.00001	....
7	....	....	....	+.000095	+.00011	....

n	M_n^{I}	M_n^{II}	M_n^{III}	M_n^{IV}	M_n^{V}	M_n^{VI}	M_n^{VII}
1	+.0025	+.0023	+.0017	+.001159	+.00093	—.0176	....
2	+.0003	+.0027	+.0093	—.006306	+.01580	....	....
3	+.0209	+.0146	+.0030	—.000040	—.00005	....	....
4	+.0099	+.0083	+.0018	—.000011	—.00002	....	....
5	—.0075	+.0054	+.0485	—.000002	—.00002	....	....
6	+.0244	—.0243	+.0338	....	....	....	....
7	....	....	....	—.001514	—.00145	....	+.0111

From these data we find the following values of E_0, E_1, &c., I_0, I_1, &c., and b.

a	E_0	E_1	E_2	E_3	E_4	E_5	E_6	E_7
2.2	+0".0502	+0".7012	—0".2301	+0".0022	—0".0041	+0".0055	+0".0089	+0".0016
2.4	+0.0670	+0.9341	—0.3116	+0.0011	—0.0024	+0.0030	+0.0045	+0.0021
2.6	+0.0890	+1.2394	—0.4173	+0.0005	—0.0014	+0.0018	+0.0025	+0.0028
2.8	+0.1179	+1.6413	—0.5568	—0.0001	—0.0007	+0.0011	+0.0016	+0.0037
3.0	+0.1564	+2.1768	—0.7431	—0.0005	—0.0002	+0.0007	+0.0010	+0.0049
3.2	+0.20 5	+2.9030	—0.9974	—0.0010	+0.0002	+0.0005	+0.0006	+0.0065

a	I_1	I_2	I_3	I_4	I_5	I_6	I_7	b
2.2	+0".0379	—0".1753	+0".0052	+0".0031	+0".0095	+0".0023	—0".0486	32".815
2.4	+0.0460	—0.2192	+0.0029	+0.0020	+0.0054	+0.0008	—0.0599	40.097
2.6	+0.0564	—0.2733	+0.0012	+0.0012	+0.0034	+0.0003	—0.0738	49.209
2.8	+0.0695	—0.3456	—0.0001	+0.0006	+0.0022	+0.0001	—0.0913	60.724
3.0	+0.0865	—0.4209	—0.0012	+0.0001	+0.0015	+0.0001	—0.1138	75.519
3.2	+0.1089	—0.5467	—0.0024	—0.0003	+0.0010	0.0000	—0.1432	94.942

In the computations of the quantities E and I, we have a test of their accuracy, because they ought to fulfil the conditions.

$$E_0 + E_1 + \dots = [0,1]\,(N'_0 + N'_1 + \dots) + [0,2]\,(N''_0 + N''_1 + \dots) + \&c.$$

$$I_1 + I_2 + I_3 + \dots = (0,1)\,(M'_1 + M'_2 + \dots) + (0,2)\,(M''_1 + M''_2 + \dots) + \&c.$$

We omit the terms dependent on M_0 in the values of I, because in the final result they will bring out $k_0 = M$, as in the equation (9).

We shall now put $\varepsilon_n = \frac{N_n}{b - g_n}$, $x_n = \frac{M_n}{b + k_n}$; and to obtain the numerical values of these quantities we shall use the following values of g, g_1, &c., k_1, k_2, &c., which are deduced from the data given in the work of Le Verrier above referred to, and are partially corrected for the terms of third order.

$g = 2.901$	$g_4 = 7.575$	$k = 0.0$	$k_4 = -7.086$
$g_1 = 3.808$	$g_5 = 17.153$	$k_1 = -3.166$	$k_5 = -17.468$
$g_2 = 22.828$	$g_6 = 17.863$	$k_2 = -26\ 568$	$k_6 = -18.568$
$g_3 = 5.299$	$g_7 = 0.693$	$k_3 = -4.795$	$k_7 = -0.756$

We thus obtain the following values of ε and $\varkappa$ for every .05 in the value of a between the limits of the mean distances of the asteroids.

TABLE I.—*For Eccentricities and Perihelia.*

a	ε	ε_1	ε_2	ε_3	ε_4	ε_5	ε_6	ε_7
2.20	+.001679	+.024174	—.023044	+.000079	—.000162	+.000352	+.000597	+.000049
2.25	.001710	.024567	.021326	.000064	.000133	.000269	.000448	.000050
2.30	.001741	.024960	.019984	.000052	·000109	.000209	.000343	.000051
2.35	.001772	.025352	.018913	.000041	.000089	.000164	.000262	000052
2.40	.001802	.025743	.018043	.000033	.000073	.000131	.000203	.000053
2.45	.001832	.026133	.017329	.000026	.000060	.000105	.000159	.000054
2.50	.001862	.026523	.016735	.000020	.000050	.000085	.000126	.000055
2.55	.001893	.026912	.016237	.000015	.000041	.000069	.000100	.000056
2.60	.001922	.027299	.015817	.000011	.000034	.000056	.000081	.000057
2.65	.001951	.027685	.015463	.000007	.000027	.000046	.000066	.000058
2.70	.001980	.028070	.015162	.000004	.000022	.000038	.000054	.000059
2.75	.002009	.028454	.014906	+.000001	.000017	.000031	.000045	.000060
2.80	.002038	.028837	.014688	—.000001	.000014	.000026	.000037	.000061
2.85	.002067	.029218	.014502	.000003	.000011	.000022	.000030	.000062
2.90	.002196	.029598	.014346	.000004	.000008	.000018	.000025	.000063
2.95	.002225	.029977	.014214	.000006	.000006	.000015	.000021	.000064
3.00	.002153	.030355	.014104	.000007	.000004	.000012	.000017	.000065
3.05	.002181	.030732	.014017	.000008	—.000002	.000010	.000014	.000066
3.10	.002309	.031107	.013935	.000009	.000000	.000008	.000012	.000067
3.15	.002237	.031481	.013875	.000010	+.000001	.000007	.000010	.000068
3.20	+.002265	+.031854	—.013831	—.000011	+.000002	+.000006	+.000008	+.000069

TABLE II.—*For Inclinations and Nodes.* TABLE III.

a	$\varkappa_1$	$\varkappa_2$	$\varkappa_3$	$\varkappa_4$	$\varkappa_5$	$\varkappa_6$	$\varkappa_7$	b
2.20	+.001277	—.028054	+000185.	+.000122	+.000616	+.000165	—.001516	32.815″
2.25	.001269	.023416	000150.	.000103	.000475	.000110	.001518	34.488
2.30	.001261	.020246	000123.	.000086	.000373	.000074	.001520	36.256
2.35	.001254	.017946	000101.	.000072	.000296	.000052	.001522	38.123
2.40	.001247	.016200	000082.	.000060	.000237	.000037	.001523	40.097
2.45	.001241	.014831	000065.	.000049	.000191	.000027	.001523	42.184
2.50	.001235	.013729	000051.	.000040	.000156	.000020	.001524	44.394
2.55	.001230	.012824	000039.	.000033	.000129	.000014	.001524	46.732
2.60	+.001225	—.012070	+000028.	+.000028	+.000106	+.000010	—.001524	49.209

a	$\varkappa_1$	$\varkappa_2$	$\varkappa_3$	$\varkappa_4$	$\varkappa_5$	$\varkappa_6$	$\varkappa_7$	b
2.65	+.001220	—.011432	+.000018	+.000023	+.000087	+.000007	—.001524	51″.833
2.70	.001216	.010886	.000009	.000018	.000071	.000005	.001524	54.619
2.75	.001212	.010413	+.000003	.000014	.000059	.000004	.001524	57.577
2.80	.001208	.010002	—.000001	.000011	.000050	.000003	.001523	60.724
2.85	.001204	.009640	.000003	.000008	.000043	.000002	.001523	64.074
2.90	.001201	.009320	.000006	.000006	.000037	.000002	.001523	67.641
2.95	.001198	.009036	.000009	.000004	.000031	.000001	.001523	71.450
3.00	.001196	.008782	.000012	.000002	.000026	.000001	.001522	75.519
3.05	.001193	.008555	.000015	+.000001	.000022	+.000001	.001522	79.875
3.10	.001191	.008350	.000019	—.000001	.000018	.000000	.001522	84.543
3.15	.001189	.008164	.000023	.000002	.000015	.000000	.001521	89.555
3.20	+.001187	—.007996	—.000027	—.000004	—.000013	.000000	—.001521	94.942

The following are the values of β, β_1, &c., γ, γ_1, &c., and M, supposing the time to be reckoned from 1800, and the longitudes from the equinox of 1850.0. $M = .027460$.

$$\begin{aligned}
\beta &= 98^\circ\ 30'\ 28'' & \gamma &= 106^\circ\ 50'\ 15'' \\
\beta_1 &= 26\ 32\ 23 & \gamma_1 &= 135\ 41\ 7 \\
\beta_2 &= 127\ 17\ 9 & \gamma_2 &= 126\ 42\ 20 \\
\beta_3 &= 86\ 27\ 45 & \gamma_3 &= 23\ 20\ 25 \\
\beta_4 &= 36\ 18\ 43 & \gamma_4 &= 262\ 48\ 16 \\
\beta_5 &= 335\ 28\ 27 & \gamma_5 &= 297\ 28\ 24 \\
\beta_6 &= 315\ 11\ 1 & \gamma_6 &= 73\ 53\ 49 \\
\beta_7 &= 74\ 2\ 14 & \gamma_7 &= 202\ 15\ 43
\end{aligned}$$

If now, we put for brevity,

$$\begin{aligned}
(0) &= \beta + g\,t & & \\
(1) &= \beta_1 + g_1\,t & [1] &= \gamma_1 + k_1\,t \\
(2) &= \beta_2 + g_2\,t & [2] &= \gamma_2 + k_2\,t \\
&\vdots & &\vdots \\
(7) &= \beta_7 + g_7\,t & [7] &= \gamma_7 + k_7\,t
\end{aligned}$$

we shall have, for the elements h, l, p, and q of any asteroid in terms of the time,

$$\left.\begin{aligned}
h &= \varepsilon \sin (0) + \varepsilon_1 \sin (1) + \varepsilon_2 \sin (2) + \dots + \varepsilon_7 \sin (7) + A \sin (B + b\,t) \\
l &= \varepsilon \cos (0) + \varepsilon_1 \cos (1) + \varepsilon_2 \cos (2) + \dots + \varepsilon_7 \cos (7) + A \cos (B + b\,t) \\
p &= M \sin \gamma + \varkappa_1 \sin [1] + \varkappa_2 \sin [2] + \dots + \varkappa_7 \sin [7] + K \sin (C - b\,t) \\
q &= M \cos \gamma + \varkappa_1 \cos [1] + \varkappa_2 \cos [2] + \dots + \varkappa_7 \cos [7] + K \cos (C - b\,t)
\end{aligned}\right\} \qquad (12)$$

A, B, $\varkappa$, and C being fixed by the values of h, l, p, and q at a given epoch. The quantities ε, ε_1, &c., $\varkappa_1$, $\varkappa_2$, &c., M, and b, are taken from Tables 1, 2, and 3, by entering with the mean distance of the asteroid as the argument.

Let us now apply these data to those asteroids the elements of which are determined with sufficient accuracy, and the eccentricities and inclinations of which are sufficiently small. The latter class may be presumed to include all those for which each of these

elements is less than 11°. The uncertainty in the present mean values of the elements is such, that no advantage will result from any attempt to carry the results to more than four places of decimals; which are, moreover, quite sufficient for our present purposes. The following are the assumed values of the longitude of perihelion, longitude of node, eccentricities, and inclinations, for January 1, 1850, of such of the asteroids fulfilling the above conditions as I have to the present time (March, 1860) been able to obtain accurate elements.

Name.	Symbol.	π	☊	e	i
Ceres	①	149° 12′.5	80° 49′.0	0.0803	10° 36′.5
Vesta	④	250 23.1	103 19.5	0.0902	7 8.1
Astræa	⑤	134 35.6	141 24.8	0.1900	5 19.6
Flora	⑧	32 57.2	110 18.3	0.1567	5 53.2
Metis	⑨	70 51.2	68 30.0	0.1234	5 35.9
Hygea	⑩	227 44.0	287 39.7	0.1005	3 47.2
Parthenope	⑪	315 57.1	125 2.6	0.0988	4 36.9
Irene	⑭	179 15.0	86 38.8	0.1652	9 7.1
Psyche	⑯	12 24.1	150 32.0	0.1363	3 3.9
Thetis	⑰	259 12.8	125 26.5	0.1268	5 35.6
Fortuna	⑲	30 8.7	211 24.9	0.1578	1 32.2
Massilia	⑳	98 16.0	206 40.2	0.1438	0 41.0
Lutetia	㉑	326 58.4	80 26.8	0.1620	3 5.2
Themis	㉔	137 37.6	36 14.3	0.1177	0 49.1
Proserpina	㉖	235 4.2	45 53.2	0.0875	3 35.7
Euterpe	㉗	87 25.4	93 36.8	0.1730	1 35.5
Bellona	㉘	122 16.1	144 43.3	0.1544	9 22.5
Amphitrite	㉙	56 52.4	356 26.8	0.0725	6 8.0
Urania	㉚	30 47.5	308 13.0	0.1268	2 6.0
Pomona	㉜	194 12.0	220 48.9	0.0824	5 29.0
Circe	㉞	149 48.3	184 47.3	0.1083	5 26.5
Fides	㊲	65 56.1	8 10.7	0.1749	3 7.2
Leda	㊳	100 29.5	296 27.8	0.1556	6 58.5
Lætitia	㊴	1 48.0	157 20.5	0.1110	10 20.8
Harmonia	㊵	1 6.3	93 29.5	0.0462	4 15.8

From these elements, and from the preceding tables, we obtain the following expressions for h, l, p, and q, in terms of the time, for the above asteroids.

Ceres. ①

$$h = .0020 \sin(0) + .0286 \sin(1) - .0148 \sin(2) + .1102 \sin(158^\circ 51' + 58''.58\, t)$$
$$l = .0020 \cos(0) + .0286 \cos(1) - .0148 \cos(2) + .1102 \cos(158^\circ 51' + 58''.58\, t)$$
$$p = M \sin\gamma + .0012 \sin[1] - .0103 \sin[2] + .0001 \sin[5] - .0015 \sin[7] + .1652 \sin(80^\circ 11' - 58''.58\, t)$$
$$q = M \cos\gamma + .0012 \cos[1] - .0103 \cos[2] + .0001 \cos[5] - .0015 \cos[7] + .1652 \cos(80^\circ 11' - 58''.58\, t)$$

Vesta. ④

$$h = .0018 \sin(0) + .0254 \sin(1) - .0188 \sin(2) - .0001 \sin(4) + .0002 \sin(5) + .0003 \sin(6)$$
$$+ .1048 \sin(231^\circ 29' + 38''.56\, t)$$
$$= .0018 \cos(0) + .0254 \cos(1) - .0188 \cos(2) - .0001 \cos(4) + .0002 \cos(5) + .0003 \cos(6)$$
$$+ .1048 \cos(231^\circ 29' + 38''.56\, t)$$

$$p = M \sin \gamma + .0013 \sin [1] - .0176 \sin [2] + .0001 \sin [3] + .0001 \sin [4] + .0003 \sin [5] - .0015 \sin [7] + .1123 \sin (107° 5' - 38''.56\, t)$$

$$q = M \cos \gamma + .0013 \cos [1] - .0176 \cos [2] + .0001 \cos [3] + .0001 \cos [4] + .0003 \cos [5] - .0015 \cos [7] + .1123 \sin (107° 5' - 38''.56\, t)$$

Astræa. ⑤

$$h = .0019 \sin (0) + .0271 \sin (1) - .0160 \sin (2) + .0001 \sin (6) + .2146 \sin (140° 31' + 48.''03\, t)$$

$$l = .0019 \cos (0) + .0271 \cos (1) - .0160 \cos (2) + .0001 \cos (6) + .2146 \cos (140° 31' + 48.''03\, t)$$

$$p = M \sin \gamma + .0012 \sin [1] - .0125 \sin [2] + .0001 \sin [5] - .0015 \sin [7] + .0830 \sin (151° 38' - 48''.03\, t)$$

$$q = M \cos \gamma + .0012 \cos [1] - .0125 \cos [2] + .0001 \cos [5] - .0015 \cos [7] + .0830 \cos (151° 38' - 48''.03\, t)$$

Flora. ⑧

$$h = .0017 \sin (0) + .0242 \sin (1) - .0230 \sin (2) - .0002 \sin (4) + .0003 \sin (5) + .0006 \sin (6) + .1323 \sin (43° 27' + 32''.86\, t)$$

$$l = .0017 \cos (0) + .0242 \cos (1) - .0230 \cos (2) - .0002 \cos (4) + .0003 \cos (5) + .0006 \cos (6) + .1323 \cos (43° 27' + 32''.86\, t)$$

$$p = M \sin \gamma + .0013 \sin [1] - .0280 \sin [2] + .0002 \sin [3] + .0006 \sin [5] + .0002 \sin [6] - .0015 \sin [7] + .1021 \sin (116° 37' - 32''.86\, t)$$

$$q = M \cos \gamma + .0013 \cos [1] - .0280 \cos [2] + .0002 \cos [3] + .0006 \cos [5] + .0002 \cos [6] - .0015 \cos [7] + .1021 \cos (116° 37' - 32''.86\, t)$$

Metis. ⑨

$$h = .0018 \sin (0) + .0256 \sin (1) - .0183 \sin (2) - .0001 \sin (4) + .0001 \sin (5) + .0002 \sin (6) + .1187 \sin (86° 19' + 39''.52\, t)$$

$$l = .0018 \cos (0) + .0256 \cos (1) - .0183 \cos (2) - .0001 \cos (4) - .0001 \cos (5) + .0002 \cos (6) + .1187 \sin (86° 19' + 39''.52\, t)$$

$$p = M \sin \gamma + .0013 \sin [1] - .0168 \sin [2] + .0003 \sin [5] - .0015 \sin [7] + .0837 \sin (67° 10' - 39''.52\, t)$$

$$q = M \cos \gamma + .0013 \cos [1] - .0168 \cos [2] + .0003 \cos [5] - .0015 \cos [7] + .0837 \cos (67° 10' - 39''.52\, t)$$

Hygea. ⑩

$$h = .0022 \sin (0) + .0315 \sin (1) - .0139 \sin (2) + .1307 \sin (216° 7' + 88''.95\, t)$$

$$l = .0022 \cos (0) + .0315 \cos (1) - .0139 \cos (2) + .1307 \cos (216° 7' + 88''.95\, t)$$

$$p = M \sin \gamma + .0012 \sin [1] - .0082 \sin [2] - .0015 \sin [7] + .0869 \sin (286° 6' - 88''.95\, t)$$

$$q = M \cos \gamma + .0012 \cos [1] - .0082 \cos [2] - .0015 \cos [7] + .0869 \cos (286° 6' - 88''.95\, t)$$

Parthenope. ⑪

$$h = .0018 \sin (0) + .0262 \sin (1) - .0173 \sin (2) + .0001 \sin (5) + .0002 \sin (6) + .0775 \sin (298° 2' + 42''.30\, t)$$

$$l = .0018 \cos (0) + .0262 \cos (1) - .0173 \cos (2) + .0001 \cos (5) + .0002 \cos (6) + .0775 \cos (298° 2' + 42''.30\, t)$$

$$p = M \sin \gamma + .0012 \sin [1] - .0148 \sin [2] + .0002 \sin [5] - .0015 \sin [7] + .0694 \sin (134° 7' - 42''.30\, t)$$

$$q = M \cos \gamma + .0012 \cos [1] - .0148 \cos [2] + .0002 \cos [5] - .0015 \cos [7] + .0694 \cos (134° 7' - 42''.30\, t)$$

Irene. ⑭

$h = .0019 \sin(0) + .0272 \sin(1) - .0159 \sin(2) + .0001 \sin(6) + .1990 \sin(178° 57' + 48''.68\, t)$

$l = .0019 \cos(0) + .0272 \cos(1) - .0159 \cos(2) + .0001 \cos(6) + .1990 \cos(178° 57' + 48''.68\, t)$

$p = M \sin\gamma + .0012 \sin[1] - .0123 \sin[2] + .0001 \sin[5] - .0015 \sin[7] + .1407 \sin(86° 57' - 48.''68 t)$

$q = M \cos\gamma + .0012 \cos[1] - .0123 \cos[2] + .0001 \cos[5] - .0015 \cos[7] + .1407 \cos(86° 57' - 48.''68 t)$

Psyche. ⑯

$h = .0022 \sin(0) + .0298 \sin(1) - .0143 \sin(2) + .1013 \sin(13° 37' + 69.''35\, t)$

$l = .0022 \cos(0) + .0299 \cos(1) - .0143 \cos(2) + .1013 \cos(13° 37' + 69.''35\, t)$

$p = M \sin\gamma + .0012 \sin[1] - .0092 \sin[2] - .0015 \sin[7] + .0453 \sin(173° 21' - 69''.35\, t)$

$q = M \cos\gamma + .0012 \cos[1] - .0092 \cos[2] - .0015 \cos[7] + .0453 \cos(173° 21' - 69''.35\, t)$

Thetis. ⑰

$h = .0018 \sin(0) + .0263 \sin(1) - .0171 \sin(2) + .0001 \sin(5) + .0002 \sin(6) + .1368 \sin(244° 30' + 43''.22\, t)$

$l = .0018 \cos(0) + .0263 \cos(1) - .0171 \cos(2) + .0001 \cos(5) + .0002 \cos(6) + .1368 \cos(244° 30' + 43''.22\, t)$

$p = M \sin\gamma + .0012 \sin[1] - .0143 \sin[2] + .0002 \sin[5] - .0015 \sin[7] + .0858 \sin(132° 57' - 43''.22 t)$

$q = M \cos\gamma + .0012 \cos[1] - .0143 \cos[2] + .0002 \cos[5] - .0015 \cos[7] + .0858 \cos(132° 57' - 43''.22 t)$

Fortuna. ⑲

$h = .0018 \sin(0) + .0261 \sin(1) - .0174 \sin[2] + .0001 \sin(5) + .0002 \sin(6) + .1302 \sin(37° 23' + 41''.84\, t)$

$l = .0018 \cos(0) + .0261 \cos(1) - .0174 \cos[2] + .0001 \cos(5) + .0002 \cos(6) + .1302 \sin(37° 23' + 41''.84\, t)$

$p = M \sin\gamma + .0012 \sin[1] - .0151 \sin[2] + .0002 \sin[5] - .0015 \sin[7] + .0383 \sin(230° 34' - 41''.84 t)$

$q = M \cos\gamma + .0012 \cos[1] - .0151 \cos[2] + .0002 \cos[5] - .0015 \cos[7] + .0383 \cos(230° 34' - 41''.84 t)$

Massilia. ⑳

$h = .0018 \sin(0) + .0258 \sin(1) - .0179 \sin(2) + .0001 \sin(5) + .0002 \sin(6) + .1535 \sin(110° 11' + 40''.49\, t)$

$l = .0018 \cos(0) + .0258 \cos(1) - .0179 \cos(2) + .0001 \cos(5) + .0002 \cos(6) + .1535 \sin(110° 11' + 40''.19\, t)$

$p = M \sin\gamma + .0012 \sin[1] - .0159 \sin[2] + .0002 \sin[5] - .0015 \sin[6] + .0238 \sin(237° 58' - 40''.49\, t)$

$q = M \cos\gamma + .0012 \cos[1] - .0159 \cos[2] + .0002 \cos[5] - .0015 \cos[6] + .0238 \cos(237° 58' - 40''.49\, t)$

Lutetia. ㉑

$h = .0018 \sin(0) + .0260 \sin(1) - .0176 \sin(2) + .0001 \sin(5) + .0002 \sin(6) + .1342 \sin(318° 48' + 41''.56\, t)$

$l = .0018 \cos(0) + .0260 \cos(1) - .0176 \cos(2) + .0001 \cos(5) + .0002 \cos(6) + .1342 \cos(318° 48' + 41''.56\, t)$

$p = M \sin\gamma + .0012 \sin[1] - .0152 \sin[2] + .0002 \sin[5] - .0015 \sin[6] + .0384 \sin(79° 54' - 41''.56\, t)$

$q = M \cos\gamma + .0012 \cos[1] - .0152 \cos[2] + .0002 \cos[5] - .0015 \cos[6] + .0384 \cos(79° 54' - 41''.56\, t)$

Themis. ㉔

$h = .0022 \sin(0) + .0315 \sin(1) - .0139 \sin(2) + .1441 \sin(147^\circ\ 40' + 89''.55\ t)$
$l = .0022 \cos(0) + .0315 \cos(1) - .0139 \cos(2) + .1441 \cos(147^\circ\ 40' + 89''.55\ t)$
$p = M \sin\gamma + .0012 \sin[1] - .0082 \sin[2] - 0015 \sin[7] + .0187 \sin(318^\circ\ 53' - 89''.55\ t)$
$q = M \cos\gamma + .0012 \cos[1] - .0082 \cos[2] - 0015 \cos[7] + .0187 \cos(318^\circ\ 53' - 89''.55\ t)$

Proserpina. ㉖

$h = .0019 \sin(0) + .0277 \sin(1) - .0155 \sin(2) + .1115 \sin(220^\circ\ 23' + 52''.15\ t)$
$l = .0019 \cos(0) + .0277 \cos(1) - .0155 \cos(2) + .1115 \cos(220^\circ\ 23' + 52''.15\ t)$
$p = M \sin\gamma + .0012 \sin[1] - .0114 \sin[2] + .0001 \sin[5] - .0015 \sin[7] + .0514 \sin(31^\circ\ 35' - 52''.15\ t)$
$q = M \cos\gamma + .0012 \cos[1] - .0114 \cos[2] + .0001 \cos[5] - .0015 \cos[7] + .0514 \cos(31^\circ\ 35' - 52''.15\ t)$

Euterpe. ㉗

$h = .0018 \sin(0) + .0253 \sin(1) - .0189 \sin(2) - .0001 \sin(4) + .0002 \sin(5) + .0003 \sin(6)$
$\quad + .1772 \sin(98^\circ\ 2' + 38''.02\ t)$
$l = .0018 \cos(0) + .0253 \cos(1) - .0189 \cos(2) - .0001 \cos(4) + .0002 \cos(5) + .0003 \cos(6)$
$\quad + .1772 \cos(98^\circ\ 2' + 38''.02\ t)$
$p = M \sin\gamma + .0013 \sin[1] - .0181 \sin[2] + .0001 \sin[3] + .0003 \sin[5] - .0015 \sin[7]$
$\quad + .0157 \sin(110^\circ\ 14' - 38''.02\ t)$
$q = M \cos\gamma + .0013 \cos[1] - .0181 \cos[2] + .0001 \cos[3] + .0003 \cos[5] - .0015 \cos[7]$
$\quad + .0157 \cos(110^\circ\ 14' - 38''.02\ t)$

Bellona. ㉘

$h = .0020 \sin(0) + .0286 \sin(1) - .0148 \sin(2) + .1665 \sin(131^\circ\ 37' + 59''.13\ t)$
$l = .0020 \cos(0) + .0286 \cos(1) - .0148 \cos(2) + .1665 \cos(131^\circ\ 37' + 59''.13\ t)$
$p = M \sin\gamma + .0012 \sin[1] - .0102 \sin[2] + .0001 \sin[5] - .0015 \sin[7] + .1517 \sin(151^\circ\ 11' - 59''.13\ t)$
$q = M \cos\gamma + .0012 \cos[1] - .0102 \cos[2] + .0001 \cos[5] - .0015 \cos[7] + .1517 \cos(151^\circ\ 11' - 59''.13\ t)$

Amphitrite. ㉙

$h = .0019 \sin(0) + .0269 \sin(1) - .0162 \sin(2) + .0001 \sin(6) + .0603 \sin(83^\circ\ 44' + 46''.97\ t)$
$l = .0019 \cos(0) + .0269 \cos(1) - .0162 \cos(2) + .0001 \cos(6) + .0603 \cos(83^\circ\ 41' + 46''.97\ t)$
$p = M \sin\gamma + .0012 \sin[1] - .0128 \sin[2] + .0001 \sin[5] - .0015 \sin[7] + .1088 \sin$
$\quad (347^\circ\ 59' - 46''.97\ t)$
$q = M \cos\gamma + .0012 \cos[1] - .0128 \cos[2] + .0001 \cos[5] - .0015 \cos[7] + .1088 \cos$
$\quad (347^\circ\ 59' - 47''.97\ t)$

Urania. ㉚

$h = .0018 \sin(0) + .0256 \sin(1) - .0186 \sin(2) - .0001 \sin(4) + .0002 \sin(5) + .0003 \sin(6)$
$\quad + .1005 \sin(41^\circ\ 26' + 38''.67\ t)$
$l = .0018 \cos(0) + .0256 \cos(1) - .0186 \cos(2) - .0001 \cos(4) + .0002 \cos(5) + .0003 \cos(6)$
$\quad + .1005 \cos(41^\circ\ 26' + 38''.67\ t)$
$p = M \sin\gamma + .0013 \sin[1] - .0174 \sin[2] + .0001 \sin[3] + .0003 \sin[5] - .0015 \sin[7]$
$\quad + .0466 \sin(295^\circ\ 24' - 38''.67\ t)$
$q = M \cos\gamma + .0013 \cos[1] - .0174 \cos[2] + .0001 \cos[3] + .0003 \cos[5] - .0015 \cos[7]$
$\quad + .0466 \cos(295^\circ\ 24' - 38''.67\ t)$

Pomona. (32)

$$h = .0019 \sin(0) + .0272 \sin(1) - .0159 \sin(2) + .0001 \sin(6) + .1157 \sin(189^\circ\, 52' + 48''.66\, t)$$
$$l = .0019 \cos(0) + .0272 \cos(1) - .0159 \cos(2) + .0001 \cos(6) + .1157 \cos(189^\circ\, 52' + 48''.66\, t)$$
$$p = M \sin\gamma + .0012 \sin[1] - .0123 \sin[2] + .0001 \sin[5] + .0015 \sin[7] + .1080 \sin(228^\circ\, 37' - 48''.66\, t)$$
$$q = M \cos\gamma + .0012 \cos[1] - .0123 \cos[2] + .0001 \cos[5] + .0015 \cos[7] + .1080 \cos(228^\circ\, 37' - 48''.66\, t)$$

Circe. (34)

$$h = .0020 \sin(0) + .0280 \sin(1) - .0152 \sin(2) + .1379 \sin(156^\circ\, 58' + 53''.97\, t)$$
$$l = .0020 \cos(0) + .0280 \cos(1) - .0152 \cos(2) + .1379 \cos(156^\circ\, 58' + 53''.97\, t)$$
$$p = M \sin\gamma + .0012 \sin[1] - .0110 \sin[2] + .0001 \sin[5] - .0015 \sin[7] + .0975 \sin(196^\circ\, 39' - 53''.97\, t)$$
$$q = M \cos\gamma + .0012 \cos[1] - .0110 \cos[2] + .0001 \cos[5] - .0015 \cos[7] + .0975 \cos(196^\circ\, 39' - 53''.97\, t)$$

Fides. (37)

$$h = .0019 \sin(0) + .0277 \sin(1) - .0155 \sin(2) + .1625 \sin(75^\circ\, 58' + 51''.55\, t)$$
$$l = .0019 \cos(0) + .0277 \cos(1) - .0155 \cos(2) + .1625 \cos(75^\circ\, 58' + 51''.55\, t)$$
$$p = M \sin\gamma + .0012 \sin[1] - .0115 \sin[2] + .0001 \sin[5] - .0015 \sin[7] + .0555 \sin(349^\circ\, 37' - 51''.55\, t)$$
$$q = M \cos\gamma + .0012 \cos[1] - .0115 \cos[2] + .0001 \cos[5] - .0015 \cos[7] + .0555 \cos(349^\circ\, 37' - 51''.55\, t)$$

Leda. (38)

$$h = .0020 \sin(0) + .0284 \sin(1) - .0150 \sin(2) + .1630 \sin(111^\circ\, 43' + 56''.97\, t)$$
$$l = .0020 \cos(0) + .0284 \cos(1) - .0150 \cos(2) + .1630 \cos(111^\circ\, 43' + 56''.97\, t)$$
$$p = M \sin\gamma + .0012 \sin[1] - .0105 \sin[2] + .0001 \sin[3] + .0015 \sin[7] + .1393 \sin(294^\circ\, 5' - 56''.97\, t)$$
$$q = M \cos\gamma + .0012 \cos[1] - .0105 \cos[2] + .0001 \cos[3] + .0015 \cos[7] + .1393 \cos(294^\circ\, 5' - 56''.97\, t)$$

Lætitia. (39)

$$h = .0020 \sin(0) + .0286 \sin(1) - .0148 \sin(2) + .0766 \sin(359^\circ\, 42' + 58''.80\, t)$$
$$l = .0020 \cos(0) + .0286 \cos(1) - .0148 \cos(2) + .0766 \cos(359^\circ\, 42' + 58''.80\, t)$$
$$p = M \sin\gamma + .0012 \sin[1] - .0102 \sin[2] + .0001 \sin[5] - .0015 \sin[7] + .1720 \sin(163^\circ\, 59' - 58''.80\, t)$$
$$q = M \cos\gamma + .0012 \cos[1] - .0102 \cos[2] + .0001 \cos[5] - .0015 \cos[7] + .1720 \cos(163^\circ\, 59' - 58''.80\, t)$$

Harmonia. (40)

$$h = .0017 \sin(0) + .0247 \sin(1) - .0208 \sin(2) - .0001 \sin(4) + .0003 \sin(5) + .0005 \sin(6) + .0126 \sin(25^\circ\, 27' + 35''.09\, t)$$
$$l = .0017 \cos(0) + .0247 \cos(1) - .0208 \cos(2) - .0001 \cos(4) + .0003 \cos(5) + .0005 \cos(6) + .0126 \cos(25^\circ\, 27' + 35''.09\, t)$$
$$p = M \sin\gamma + .0013 \sin[1] - .0223 \sin[2] + .0001 \sin[3] + .0001 \sin[4] + .0005 \sin[5] + .0001 \sin[6] - .0015 \sin[7] + .0656 \sin(99^\circ\, 41' - 35''.09\, t)$$
$$q = M \cos\gamma + .0013 \cos[1] - .0223 \cos[2] + .0001 \cos[3] + .0001 \cos[4] + .0005 \cos[5] + .0001 \cos[6] - .0015 \cos[7] + .0656 \cos(99^\circ\, 41' - 35''.09\, t)$$

From the preceding expressions, we easily deduce the following conclusions: —

1. Harmonia is the only asteroid, among those whose elements are well determined,

the orbit of which can ever approach indefinitely near the circular form. Doris may possibly be found to be an additional asteroid in this class.

2. Euterpe is the only known asteroid the orbit of which can ever approach indefinitely near the invariable plane of the planetary system.

3. The perihelion of each asteroid (Harmonia, Doris, and Euterpe excepted) revolves nearly in the same time as its node, the time of revolution varying from about 15,000 to 40,000 years.

4. The following are the greatest and least values which can be attained by the eccentricities and inclinations to the invariable plane of the orbits of the asteroids included in the preceding tables: —

Asteroid.	Greatest Eccentricity.	Least Eccentricity.	Greatest Inclination.	Least Inclination.
			° ′	° ′
Ceres	0.1556	0.0648	10 13	8 43
Vesta	0.1514	0.0582	7 38	5 13
Astræa	0.2598	0.1696	5 38	3 53
Flora	0.1823	0.0823	7 40	4 2
Metis	0.1648	0.0726	5 56	3 39
Hygea	0.1783	0.0831	5 37	4 22
Parthenope	0.1231	0.0319	5 0	2 58
Irene	0.2441	0.1539	8 56	7 12
Psyche	0.1476	0.0550	3 17	1 55
Thetis	0.1823	0 0913	5 54	3 56
Fortuna	0.1758	0.0846	3 14	1 10
Massilia	0.1993	0.1077	2 26	0 17
Lutetia	0.1799	0.0885	3 12	1 8
Themis	0.1917	0.0965	1 42	0 27
Proserpina	0.1566	0.0664	3 46	2 8
Euterpe	0.2238	0.1306	2 7	0 00
Bellona	0.2119	0.1211	9 26	7 57
Amphitrite	0.1054	0.0152	7 7	5 20
Urania	0.1471	0.0539	3 51	1 29
Pomona	0.1608	0.0706	7 3	5 20
Circe	0.1831	0.0927	6 23	4 48
Fides	0.2076	0.1174	4 0	2 22
Leda	0.2084	0.1176	8 45	7 13
Lætitia	0.1220	0.0312	10 36	9 7
Harmonia	0.0607	0.0000	5 15	2 16

§ 2.

We now have the necessary data for investigating the questions referred to in the beginning of this paper. Since it is deducible from Olbers's hypothesis that the orbits of all the asteroids once intersected each other in a common point, we may first find whether it is possible or probable that there ever was such intersection. I have considered this question in Gould's Astronomical Journal, No. 129, with reference to the asteroids Vesta and Hygea, and there shown that, although the aphelion distance of Vesta sometimes exceeds the perihelion distance of Hygea, an intersection of their orbits is

not possible so long as the equations (12) of the preceding section will give nearly true values of the elements by attributing any values whatever to the angles (1), (2), (3), &c. In order that any conclusion that one may draw respecting this question may rest on as broad a foundation as possible, we shall now consider the same question with respect to other asteroids.

In the paper referred to, it is shown that an intersection of the orbits is not possible unless their elements and secular coefficients are such as to fulfil the condition

$$(k'h - k\,h')^2 + (k'l - k\,l')^2 > (k' - k)^2,$$

k' representing the semi-parameter of the outer orbit, and k that of the other. Substituting for h and l their expressions in the preceding section, and putting $B + b\,t = N$, $B' + b'\,t = N'$, this inequality will take the form

$$\begin{aligned} &- 2\,k\,k'\,A\,A' \cos(N' - N) - 2\,\Sigma_n\,k\,A'\,(k'\varepsilon_n - k'\,\varepsilon_n) \cos(N' - (n)) \\ &+ 2\,\Sigma_n\,k'\,A'\,(k'\varepsilon_n - k\,\varepsilon'_n) \cos(N - n) + 2\,\Sigma_m\,\Sigma_n\,(k'\varepsilon_m - k\,\varepsilon'_m)\,(k'\varepsilon_n - k\,\varepsilon'_n) \cos((m) - (n)) \qquad (13) \\ &\qquad > (k' - k)^2 - \Sigma\,(k'\varepsilon - k\,\varepsilon')^2 - k'^2\,A^2 - k^2\,A'^2. \end{aligned}$$

If A and A' are both small, the eccentricities of the orbits will likewise be small, and k and k' will be subject to only very slight variations. If we suppose k and k' constant, the maximum value of the first member of the above inequality will be, after transposing the last three terms,

$$\{k'\,A + k\,A' + \Sigma \pm (k'\varepsilon - k\,\varepsilon')\}^2,$$

and by finding the value of this expression, using the mean values of the parameters k' and k, and so taking the doubtful signs that the value of this expression shall be the greatest possible, we may at once find whether an intersection of the orbits is possible, by observing whether the condition $k'\,A + k\,A' \pm \Sigma\,(k'\varepsilon - k\,\varepsilon') > k' - k$ is fulfilled.

If A and A' are both large, the first member of the above inequality can attain its greatest magnitude only when we have very nearly $N^1 - N = 180°$. If this condition is fulfilled, the eccentricity of the one orbit will be at its maximum when that of the other is at its minimum. The second member of (13) will attain its least magnitude when the eccentricity of the outer planet is at its maximum, and that of the inner one at its minimum; that is when we have

$$\left.\begin{aligned} &(0) = (1) = (3) = (5) = (6) = (7) = N' \\ &(2) = (4) = N = 180° - N' \end{aligned}\right\} \qquad (14)$$

But, since $k'\,\varepsilon - k\,\varepsilon'$ has in general the same sign as ε, it is evident from an inspection of (13), that these conditions will also make its first member attain its least magnitude;

and, as the change is in each member of the same order of magnitude, the planets having large eccentricities can be treated without great error in nearly the same manner as those for which this element is small. We may, however, obtain a more simple inequality than (13), which will have the advantage of enabling us to ascertain how near any number of asteroids could ever have come to a common point of intersection. Suppose the conditions (14) to be fulfilled. Then suppose any one of the angles (0), (1), (2), to vary, and let it differ by the quantity α from its first value. Then the second member of (13) will, in consequence of the change in the eccentricities of the planets, change its value by a quantity very nearly of the form $\mu \cos \alpha$, and the change in the first member will evidently be of the same form, and may be represented by $\mu' \cos \alpha$. μ' and μ are one half the changes which the first and second members of (13) respectively undergo by a change of 180° in the value of the angle. Hence the state of the orbits most favorable to (13) will be found either when $\alpha = 0$, or when $\alpha = 180°$, according to the relative magnitudes of μ and μ'. The perihelion of the outer planet will then have the same longitude as the aphelion of the inner one; and since in the state supposed the eccentricities of the orbits are equal to $(A' \pm \varepsilon \pm \varepsilon_1 \pm \varepsilon_2 \ldots)$ and $(A \mp \varepsilon \mp \varepsilon_1 \mp \varepsilon_2 \ldots)$, it follows that the condition of possibility of intersection will be

$$a(1 + A \pm \varepsilon \pm \varepsilon_1 \pm \varepsilon_2 \ldots \pm \varepsilon_7) > a'(1 - A \mp \varepsilon' \mp \varepsilon_1' \ldots \mp \varepsilon'_7); \qquad (15)$$

the corresponding ε's having opposite signs in the two members, and being so taken as most to favor the condition. From Table I. it is evident that ε, ε_1, and ε_7 should be taken negatively (without regard to their signs in the Table); while ε_3, ε_4', &c. should be taken positively; and ε_2 is doubtful, but would generally have to be taken positively. ε', ε'_1, and ε_7 must therefore be regarded as positive, and the other ε's as negative.

From this, and from the preceding numerical expressions for the secular variations, we deduce the following system of values of the eccentricities, and consequent perihelion and aphelion distances of certain of the asteroids which lie near the extreme limits of the zone, as being those most favorable to the intersection of their orbits in a common point.

Outer Asteroids.			Inner Asteroids.		
	Eccentricities.	Perihelion Distances.		Eccentricities.	Aphelion Distances.
Hygea	.1505	2.68	Vesta	.0968	2.58
Themis	.1639	2.63	Flora	.1304	2.49
Psyche	.1190	2.58	Metis	.1101	2.65
Lætitia	.1024	2.49	Urania	.0925	2.58
			Harmonia	.0077	2.29

From these values it follows that while the coefficients ε, ε_1, &c. and A have the

values assigned to them in the preceding investigation, the orbit of Hygea could never have intersected with that of Vesta, Flora, Metis, Urania, or Harmonia; the orbit of Themis could never have intersected with that of Vesta, Flora, Metis, or Harmonia; and that of Psyche could never have intersected with that of Flora or Harmonia.

It is also to be remarked that the angles (0), (1), (2), &c. are entirely independent of the circumstances of the explosion, being functions of the time alone, and that therefore the chances are tens of thousands to one against their all having had, at the time of the explosion, values near those which have been here assumed for them.

The question now arises whether this result can be considered conclusive against Olbers's hypothesis. Three possible sources of inaccuracy are to be considered: —

1. The effect of the quantities of the third order, neglected in the analysis and computations.

2. The effects of the mutual attraction of the asteroids.

3. The possible action, on the asteroids, of other forces than that of gravitation.

The quantities of the third order would not probably affect the eccentricities by a greater amount than two or three units in the third place of decimals. If so, they would not materially change the character of the preceding result.

Two asteroids might, by their mutual attraction, change each other's mean distance very materially, provided that they passed sufficiently near each other. Two asteroids, taken at random, might be expected to pass within 10,000 miles of each other about once in four hundred millions (400,000,000) of years, and therefore *some* two asteroids might be expected to pass this near each other about once in 250,000 years. If the magnitude of the largest asteroids is, as we might judge from their brilliancy, the hundred-thousandth part that of the earth, an approach of another asteroid within ten thousand miles of it would be sufficient to cause a material change in the mean motion of the latter. It does not, therefore, seem possible absolutely to disprove Olbers's hypothesis, by an attempt at rigorous computations of the secular variations of the asteroids.

The only force besides the attraction of gravitation which it will be worth while to consider, is the resistance of a medium. If, as Encke supposes, the celestial spaces are pervaded by a very rare resisting medium, it does not seem at all improbable that, during the millions of years which may have been occupied by the asteroids in moving through it, their orbits may have been so altered by its action as to invalidate our conclusions, drawn from reasoning in which the effect of this action has been neglected. Our next question will then be that of the third section.

§ 3.

Have the Orbits of the Asteroids ever been materially affected by a resisting Medium?

It is highly probable that all the asteroids are of nearly the same density; it is at least highly improbable that there exists any relation between the density and the magnitude, by virtue of which the smaller asteroids are more dense than the larger ones. If, then, these bodies are retarded by the action of a resisting medium, we may expect to see its effect more manifest on the small ones than on the large ones; the resistance being proportional to the superficial area, while the inertia is proportional to the mass, and probably to the volume. If, then, the large and small asteroids were originally arranged indiscriminately with respect to their distance from the sun, the effect of a resisting medium would be manifested in a tendency among the smaller asteroids to be nearer the sun than the larger ones. If we represent the mass of an asteroid by m, and the number of asteroids by n, the condition of indiscriminate arrangement would be

$$\frac{\Sigma\, m a}{\Sigma\, m} = \frac{\Sigma\, a}{n} \pm \beta;$$

in which β is a quantity of the order of magnitude of the chance errors of distribution; which diminishes inversely as the square root of n; and therefore vanishes when n is infinite. A tendency in the smaller asteroids to be near the sun will be manifested by the quantity $\frac{\Sigma\, m a}{\Sigma\, m} - \frac{\Sigma\, a}{n}$ being greater than any probable value of β, and *vice versa*, a tendency in the larger asteroids to be near the sun will be manifested by the same expression being negative, and greater than any probable value of β.

Unfortunately, however, if we apply this method to the actual case now in question, we shall fall into error from a cause which seems unavoidable. In fact, an asteroid near the sun will be more easily discovered than a more distant one of the same magnitude, owing to its greater brilliancy; and this circumstance is of itself sufficient to cause a tendency in the smaller known asteroids to be near the sun, though no such tendency should exist in the whole group, known and unknown. We could eliminate the effects of this cause, provided that we knew the general law which connects any assumed magnitude with the number of asteroids of that magnitude. But such a law can be derived only from observation, and the discussion of the observations will be subject to the same difficulty with the application of the test. Still, we may make some deductions respecting the effect of a resisting medium by considering its different effects on bodies of different magnitudes.

Judging from its brilliancy, Atalanta is the smallest known asteroid. Its brilliancy is only about $\frac{1}{150}$ as great as would be that of Vesta at the same distance. Its mean distance is 2.748, — considerably greater than the average. Supposing that by the resistance of a medium it was brought from the farthest limit of the zone of the asteroids to the position in which we find it, it would have been caused to approach the sun by the amount .407. The brilliancy of different asteroids at equal distances being proportional to the squares of their diameters, while the effect of the resisting medium is inversely proportional to their diameters, the effect of the medium on Vesta would be only $\frac{1}{12}$ as great as on Atalanta; the mean distance of the latter would, therefore, have been diminished by 0.034; and this we may regard as the extreme limit of the possible change in the mean distance of Vesta from this cause.

Hygea is smaller than Vesta, and Themis smaller than either Vesta or Flora. Hence, if these asteroids have been affected by a medium, the former positions of their orbits were more unfavorable for a common point of intersection than their present ones; hence our conclusions respecting the possibility of a common point of intersection are not invalidated by our not having taken into account the action of this possible cause. Moreover, one effect of the medium would be to increase the eccentricities of all the asteroids, and for this reason the former forms of the orbits were less favorable to intersection if this cause has acted.

§ 4.

Of the Relations between the Masses of the Asteroids and certain Elements of their Orbits.

On any probable hypotheses that we can make respecting the cause of an explosion of a planet, the smaller fragments ought, on the whole, to be thrown off with a greater velocity than the larger ones. Moreover, when, as in the case of the asteroids, each fragment is very small compared with the original mass, it seems at least highly probable that the velocities of those thrown in any one direction would be nearly the same, on the whole, as the velocities of those thrown in a direction at right angles to that of the first.

Thus we have two probable tests of Olbers's hypothesis. To apply them, we shall first deduce certain relations between the velocity with which a fragment would be thrown, and the elements of the orbit in which it would afterwards move.

For this purpose, take, for the axis of X, a line passing through the sun and the position of the planet at the time of the explosion, let the axis of Y be in the plane of the orbit of the planet, and that of Z perpendicular to it. Represent by a_0 the distance of the planet from the sun, and by ξ and ζ the velocities of the projected fragments

in the direction of the axes of X and Z respectively; and by η the velocity in the direction of the axis of Y relatively to that of a planet moving in a circular orbit at the distance a_0. ξ, η, and ζ will then be equal to the velocities of projection of the fragment in the directions of the corresponding axes, plus the velocities of the planet in the same direction over and above those due to a circular orbit.

The only elements which we can determine are the eccentricity, inclination, and the amount by which the mean distance differs from a_0. In determining these, we may, in a rough approximation like the present, neglect all quantities of the second order with respect to the velocities of projection ξ, η, and ζ. Represent by δa the difference between a_0 and a, the latter being the mean distance of the fragment after its projection, by v_0 the velocity of the planet in a circular orbit, and by v the actual velocity of the fragment after projection. We then have

$$\frac{1}{a} = \frac{2\,k^2 - a_0 v^2}{a_0\,k^2}; \quad v^2 = (v_0 + \eta)^2 + \xi^2 + \zeta^2.$$

We then obtain by suitable reductions, neglecting quantities of the second order, and observing that $v_0 = \frac{k}{a_0^{\frac{1}{2}}}$,

$$\delta a = \frac{2\,a_0^{\frac{3}{2}}\,\eta}{k}, \tag{16}$$

k here representing the Gaussian constant.

Representing for the present by p the parameter of the orbit, we have

$$p = \frac{a_0^2\,(v^2 - \xi^2)}{k^2}$$

$$\frac{p}{a} = \frac{a_0}{k^2}\left(2\,v^2 - 2\,\xi^2 + \frac{a_0^2\,v^2\,\xi^2}{k^2} - \frac{a_0^2\,v^4}{k^2}\right)$$

$$e^2 = 1 - \frac{p}{a} = \frac{1}{k^2}\left(k^2 - 2\,a_0\,v^2 + 2\,a_0\,\xi^2 - \frac{a_0^2\,v^2\,\xi^2}{k^2} + \frac{a_0^2\,v^4}{k^2}\right).$$

But by the conditions of circular motion

$$-\,k^2 + 2\,a_0\,v_0^2 - \frac{a_0^2\,v_0^4}{k^2} = 0.$$

Wherefore

$$e^2 = \frac{1}{k^2}\left(2\,a_0\,(v_0^2 - v^2) + 2\,a_0\,\xi^2 - \frac{a_0^2\,v_0^2\,\xi^2}{k^2} + \frac{a_0^2\,(v^4 - v_0^4)}{k^2}\right).$$

Developing the expressions within the parenthesis to quantities of the second order inclusive, and observing that $\frac{v_0^2}{k^2} = \frac{1}{a_0}$, we find

$$e^2 = \frac{a_0\,(\xi^2 + 4\,\eta^2)}{k^2}; \quad e = \frac{\sqrt{a}\,(\xi^2 + 4\,\eta^2)}{k}. \tag{17}$$

For the inclination we easily find

$$i = a_0^{\frac{1}{2}}\,\frac{\zeta}{k}. \tag{18}$$

If the eccentricity of the planet before the explosion were small, the mean values of ξ, η, and ζ would be very nearly the mean velocity of projection of the fragments.

Representing by λ, λ', and λ'' the angles which the direction of projection of any fragment makes with the axes of co-ordinates, by α the velocity of projection, and by ξ_0, η_0, and ζ_0 the velocities of the planet in the direction of the three axes relatively to the velocity due to a circular orbit, we have

$$\xi = \xi_0 + \alpha \cos \lambda$$
$$\eta = \eta_0 + \alpha \cos \lambda'$$
$$\zeta = \zeta_0 + \alpha \cos \lambda''.$$

Since by hypothesis $\cos \lambda$ has all values at random between $+1$ and -1, and ξ_0 and η_0 are small compared with α, any small positive value of ξ_0 will diminish the absolute numerical values of ξ for the several fragments for which $\alpha \cos \lambda$ is negative nearly as much as it will increase those values for the fragments for which $\alpha \cos \lambda$ is positive, and *vice versa*. A similar remark will of course apply to η and ζ. On the whole, however, the mean values of ξ, η, and ζ, taken without regard to their signs, will be increased by a quantity of the order of magnitude of $\frac{\xi_0^2}{\alpha}$, $\frac{\eta_0^2}{\alpha}$, $\frac{\zeta_0^2}{\alpha}$, respectively.

A comparison of (17) and (18) shows that the mean value of the eccentricities of the fragments ought to be nearly $\sqrt{5}$ times as great as that of the inclinations; and that the mean value of $\frac{\delta a}{a}$ should be about twice as great as that of the inclinations, or a little less than that of the eccentricities.

From the equations (16), (17), and (18), we easily obtain expressions for ξ, η, and ζ in terms of the elements. They are,

$$\xi = k \sqrt{\frac{a^2 e^2 - 2 \delta a^2}{a_0^3}}; \; \eta = k \frac{\delta a}{2 a^{\frac{3}{2}}}; \; \zeta = k \frac{i}{a_0^{\frac{1}{2}}}. \qquad (19)$$

To apply these equations rigorously, we should know the values of the eccentricities and inclinations of the several fragments immediately after the explosion. But from the equation (15) of § 2, it appears that the eccentricities of the fragments must immediately after the explosion have been quite near their mean values; moreover, the eccentricities and inclinations are subject to but comparatively slight variations, as they will very rarely approach either of the limits given on page 138. We shall, therefore, use the mean values of those elements for the asteroids whose secular variations are given in § 1, and the present values for those which are not there included.

The mean of the perihelion distances of the outer asteroids given in the Table in § 2 is 2.60, and the mean of the aphelion distances of the inner ones is 2.52. The mean of these may be taken as the most probable value of a_0, which we shall therefore put equal to 2.56.

Symbol.	e_0	δa	$\frac{a^{\frac{1}{2}}}{k}\xi$	$\frac{a^{\frac{1}{2}}\eta}{k}$	$\frac{a^{\frac{1}{2}}\zeta}{k}$	$\frac{a^{\frac{1}{2}}v}{k}$	v	M	m_n
(1)	0.114	+0.21	0.08	0.04	0.17	0.19	2.3	251	48
(2)	0.239	+0.21	0.23	0.04	0.57	0.61	7.2	166	46
(3)	0.256	+0.11	0.25	0.02	0.22	0.34	4.0	66	45
(4)	0.108	−0.20	0.27	−0.04	0.12	0.15	1.8	234	47
(5)	0.218	+0.02	0.22	0.00	0.08	0.23	2.7	17	26
(6)	0.202	−0.13	0.19	−0.03	0.26	0.33	3.9	44	42
(7)	0.231	−0.17	0.22	−0.03	0.10	0.25	3.0	40	40
(8)	0.136	−0.36	0.09 $\sqrt{-1}$	−0.08	0.10	(0.13)	(1.5)	19	30
(9)	0.122	−0.17	0.11	−0.03	0.11	0.16	1.9	30	38
(10)	0.134	+0.59	0.15 $\sqrt{-1}$	0.10	0.09	(0.14)	(1.8)	55	44
(11)	0.084	−0.11	0.07	−0.02	0.07	0.10	1.2	20	31
(12)	0.219	−0.23	0.20	−0.05	0.15	0.25	3.0	14	22
(13)	0.085	+0.02	0.08	0.00	0.30	0.31	3.7	18	27
(14)	0.201	+0.03	0.20	0.01	0.14	0.24	2.8	22	33
(15)	0.187	+0.08	0.18	0.02	0.21	0.28	3.3	43	41
(16)	0.106	+0.36	0.06 $\sqrt{-1}$	0.06	0.05	(0.08)	(1.0)	29	35
(17)	0.140	−0.09	0.14	−0.02	0.09	0.16	1.9	14	24
(18)	0.217	−0.26	0.18	−0.06	0.18	0.27	3.2	14	23
(19)	0.134	−0.12	0.13	−0.02	0.04	0.14	1.7	16	25
(20)	0.157	−0.15	0.15	−0.03	0.03	0.15	1.8	22	32
(21)	0.138	−0.12	0.13	−0.02	0.04	0.14	1.7	12	19
(22)	0.104	−0.06	0.10	−0.01	0.24	0.26	3.1	8	9
(23)	0.232	+0.07	0.23	0.01	0.18	0.29	3.4	7	8
(24)	0.147	+0.59	0.14 $\sqrt{-1}$	0.10	0.03	(0.10)	(1.4)	10	16
(25)	0.253	−0.16	0.25	−0.03	0.37	0.44	5.2	7	7
(26)	0.115	+0.10	0.11	0.02	0.08	0.14	1.7	10	14
(27)	0.183	−0.21	0.16	−0.04	0.03	0.17	2.0	11	18
(28)	0.170	+0.22	0.15	0.04	0.15	0.22	2.6	29	36
(29)	0.068	−0.01	0.07	−0.00	0.11	0.13	1.5	36	39
(30)	0.105	−0.20	0.07	−0.04	0.05	0.09	1.1	10	13
(31)	0.216	+0.60	0.14	0.10	0.46	0.49	5.8	11	17
(32)	0.119	+0.03	0.12	0.01	0.11	0.13	1.5	7	4
(33)	0.337	+0.31	0.32	0.06	0.03	0.33	3.9	8	10
(34)	0.131	+0.13	0.12	0.03	0.10	0.16	1.9	5	3
(35)	0.221	+0.42	0.17	0.07	0.14	0.23	2.7		
(36)	0.298	+0.19	0.29	0.04	0.33	0.44	5.2	2	1
(37)	0.165	+0.08	0.16	0.02	0.06	0.17	2.0	12	21
(38)	0.166	+0.18	0.15	0.03	0.14	0.21	2.5	10	15
(39)	0.092	+0.21	0.05	0.04	0.17	0.18	2.1	46	43
(40)	0.035	−0.29	0.11 $\sqrt{-1}$	−0.07	0.07	(0.09)	(1.1)	19	29
(41)	0.202	−0.16	0.19	−0.03	0.28	0.34	4.0		
(42)	0.223	−0.13	0.21	−0.03	0.15	0.26	3.1	7	5
(43)	0.168	−0.36	0.05	−0.08	0.06	0.13	1.5	7	6
(44)	0.147	−0.13	0.14	−0.03	0.07	0.15	1.8	8	11
(45)	0.085	+0.18	0.05	0.03	0.12	0.14	1.6	9	12
(46)	0.169	+0.22	0.17	0.00	0.04	0.17	2.0	2	2
(47)	0.128	+0.32	0.04	0.06	0.09	0.12	1.4	30	37
(48)	0.077	+0.55	0.18 $\sqrt{-1}$	0.09	0.11	(0.14)	(1.7)	12	20
(49)	0.238	+0.53	0.16	0.09	0.06	0.19	2.0	18	28
(50)	0.287	+0.09	0.28	0.02	0.05	0.29	3.4	23	34
(51)	0.063	−0.18	0.05 $\sqrt{-1}$	−0.04	0.18	(0.18)	(2.1)		
(52)	0.102	+0.54	0.15 $\sqrt{-1}$	0.09	0.13	(0.16)	(2.0)		
(53)	0.180	+0.05	0.18	0.01	0.09	0.20	2.4		
(54)	0.188	+0.16	0.18	0.03	0.20	0.27	3.2		
(55)	0.134	+0.22	0.11	0.04	0.13	0.17	2.0		
(56)	0.203	−0.03	0.20	−0.01	0.13	0.24	2.8		
(57)	0.106	+0.59	0.17 $\sqrt{-1}$	0.10	0.26	(0.29)	(3.4)		

The computation of ξ, η, and ζ, with the data necessary thereto, are given in the preceding table.

In this I have also included the quantities necessary for finding whether there exists any relation between the magnitudes of the asteroids, and the quantities ξ, η, and ζ, or the velocities with which they were projected. The second column gives the value of the eccentricity used in the computation; and the third the difference between the actual mean distance of the asteroid and 2.56. Then follow the values of $a^{\frac{1}{2}}\xi$, $a^{\frac{1}{2}}\eta$, and $a^{\frac{1}{2}}\zeta$, as given by the formulæ (19). The seventh column contains the values of $a^{\frac{1}{2}}v$, which is proportional to the probable absolute velocity of projection of the asteroid, v being equal to $\sqrt{\xi^2+\eta^2+\zeta^2}$. To express these velocities in ordinary astronomical units, they must be multiplied by $\frac{\text{Gaussian } k}{\sqrt{2.56}}$. If we take the earth's mean distance, and the solar day, as the units of space and time respectively, this factor will be .0107; and if for these units we take the English mile and the solar second, the factor will be 11.95. The eighth column gives the absolute velocity of projection of the asteroid, in miles per second. These numbers are not to be regarded as absolutely accurate, being separately subjected to possible errors of 4 or 5 in the last place. But from what precedes, it will be seen that the mean of a considerable number of them will be nearly exact. When ξ is imaginary, its value has been supposed zero in computing v, and the latter has been put between parentheses.

The column marked M gives a series of numbers proportional to the superficial area of the asteroids, as deduced from their brilliancy. The square roots of these numbers will therefore be proportional to the diameters of the asteroids. In obtaining the values of M, I have used the table of apparent magnitudes published by Mr. Pogson in the Monthly Notices of the Royal Astronomical Society, for January, 1859.

The column headed m_n gives a series of numbers showing the order of magnitude of the forty-eight asteroids contained in Mr. Pogson's table.

It will be observed that a considerable number of the values of ξ are imaginary. These values pertain to those orbits of which, with the tabular eccentricity, the perihelion distance is greater, or the aphelion distance less, than 2.56. The real values of ξ are on the whole very nearly the same as those of ζ; if we regard the imaginary values as zero, ξ will on the whole be sensibly less than ζ. Still their agreement is quite remarkable, and this favors Olbers's hypothesis, since, as before remarked, it is what might naturally be expected if this hypothesis were true. But the values of η are far less than those of ξ and ζ, which indicates that those fragments which were projected in the direction of the line of motion of the planet were thrown with much

less velocity than the others. To the smallness of η is alone due the fact, that the eccentricities are not as many times larger than the inclinations as would be required on the hypothesis of explosion. Now this smallness of η may be accounted for on Olbers's hypothesis, if we reflect that all the asteroids for which $a^{\frac{1}{2}}\eta$ is greater than .120 would be thrown without the limit of the zone in which they are now found; and that owing to their consequent frequent approach to Jupiter when in their aphelion, or to Mars when in their perihelion, their orbits might be entirely deranged.

We may now determine whether there exists between the masses of the asteroids, and the velocities with which, on Olbers's hypothesis, they were thrown, any relation in virtue of which the smaller asteroids were thrown with greater velocity than the larger ones, or *vice versa*. This question would be solved with most theoretical rigor as follows: — If n asteroids be numbered in the order of their magnitude, and also in the order of their velocity of projection, if m_n represents the number of any asteroid in the order of magnitude, and v_n in the order of velocity of projection, then will the condition of no relation between these two classes of numbers be, when n is large,

$$\frac{4\,\Sigma\, m_n\, v_n}{n+1} = n^2 \pm \beta,$$

β being a small quantity of the order of magnitude of the chance errors of distribution, or of $n^{\frac{3}{2}}$. But a more simple method will give a result practically quite as good. If we take the forty-eight asteroids of which both the magnitudes and velocities are given, we find that the average velocity of projection of that half of which the magnitude is greatest is .209, or about 2.49 miles per second; and of that half of which the magnitude is least, .217, or about 2.59 miles per second. This difference is much less than that which might result from the chance inequalities; hence no relation like that sought for exists between the masses of the asteroids, and the velocities with which they were projected, if Olbers's hypothesis be true.

The velocities η are, some positive, others negative, which indicates that the fragments must have been projected both backward and forward with respect to the direction of the planet's motion. The signs of ξ and ζ it is not possible to determine, since the eccentricity and inclination of a fragment would have the same value, whether these quantities were positive or negative.

In finding the values of ζ, no allowance could be made for the latitude of the planet at the time of the explosion. This must have been very small relative to the invariable plane, else the inferior limits of the inclinations of none of the asteroids could have been nearly zero.

§ 5.

Of certain observed Relations among the Orbits of the Asteroids, which are the Result, in whole or in part, of known Causes.

It has frequently been noticed by writers on the distribution of the asteroids, that the perihelia and nodes of these bodies are very unequally distributed in longitude. For about two thirds of the asteroids, these elements are found in the first semicircle of longitude.

These inequalities of distribution proceed principally from the fact that some of the principal terms in the expressions for h, l, p, and q, given in § 1, have common angles for all the asteroids, and that the coefficients of each of these angles have the same sign for the different asteroids. Thus in the expressions (12) the terms

$$\varepsilon \sin(0) + \varepsilon_1 \sin(1) + \varepsilon_2 \sin(2) + \ldots + \varepsilon_7 \sin(7),$$

and

$$\varepsilon \cos(0) + \varepsilon_1 \cos(1) + \varepsilon_2 \cos(2) + \ldots + \varepsilon_7 \cos(7),$$

are common to all the asteroids, the different ε's all having the same sign when they are of appreciable magnitude. The average value of the first of these expressions is about $+.0011$; and of the second, about .0314. These common terms, therefore, cause a tendency in the perihelia to be near the longitude of which the tangent is $\frac{11}{314}$, or very nearly 0°. About 33 of the 57 known asteroids have their perihelia within 90° of this point of longitude. This is but one more than the probable number which we should expect as the effect of the above-mentioned tendency. The perihelia are distributed in the four quadrants as shown in the second column of the following table. The third column shows the probable number, taking into account the above-mentioned tendency.

1	22	16
2	15	13
3	9	12
4	11	16

The excess of the number in the first quadrant over that in the fourth, and of the number in the second quadrant over that in the third, proceeds from the unequal distribution of the angles B around the circle; and this again is merely a chance temporary accumulation of those angles in the first two quadrants, which, from their expressions in § 1, will evidently not be permanent, but will wear away in the course of a few thousand years, and which did not exist a few thousand years ago.

The expressions for p and q of all the asteroids contain the common terms

$$M \sin \gamma + k_1 \sin [1] + k_2 \sin [2] + \ldots . + k_7 \sin [7],$$

and

$$M \cos \gamma + k_1 \cos [1] + k_2 \cos [2] + \ldots . + k_7 \cos [7].$$

The mean value of the first of these is about $+.0180$, and that of the second very small. Hence a common tendency exists among the nodes of the asteroids to be in 90° of longitude. The second and third columns of the following table exhibit the real and the probable distribution.

1	15	15
2	20	16
3	13	13
4	9	13

The excess of the number in the third quadrant over that in the fourth proceeds from a cause similar to that which produces the excess in the perihelia, above referred to.

In the general expressions for the eccentricity, inclination, longitude of perihelion, and longitude of node of Jupiter, the principal terms are

$$h_{IV} = + .0031 \sin (0) + .0427 \sin (1) - .0155 \sin (2)$$
$$l_{IV} = + .0031 \cos (0) + .0427 \cos (1) - .0155 \cos (2).$$
$$p_{IV} = M \sin \gamma + .0012 \sin [1] - .0063 \sin [2] - .0015 \sin [7]$$
$$q_{IV} = M \cos \gamma + .0012 \cos [1] - .0063 \cos [2] - .0015 \cos [7].$$

The comparison of the coefficients in these terms with the values of the corresponding ε's and $\varkappa$'s given in Tables I. and II. of § 1, show that the corresponding quantities have the same signs, and that the different ratios of their magnitudes do not differ very materially from each other. The cause of this relation is, moreover, evident from an examination of the process by which the values of ε and $\varkappa$ were obtained. It follows from it that the general law of grouping of the nodes and perihelia of the asteroids may be expressed by saying that there is always a tendency in the perihelia of the asteroids to coincide in longitude with the perihelion of Jupiter, and in their nodes to coincide in longitude with the node of Jupiter. Sometimes, however, this tendency may be more than compensated by the circumstance of a number of the angles $B + b\,t$ and $C - b\,t$ having values nearly 180° different from the longitude of the perihelion, or longitude of the node of Jupiter. It will be most manifest in those asteroids which have small eccentricities and inclinations; thus the perihelion of Harmonia will very rarely be as much as 90° distant from that of Jupiter. For a similar reason the mutual inclination of the orbits of Euterpe and Jupiter will always be quite small, it being represented very nearly by $\sqrt{(p' - p)^2 + (q' - q)^2}$.

The fact that the orbit of every asteroid, or nearly every one, is interlinked with the orbits of one or more other asteroids, so that if they were material we should by removing one carry off all the others with it, has sometimes been adduced as indicating a connection of some sort between these bodies. Let us examine the conditions of such interlinking. Suppose that one orbit of any pair is revolved around its node on the other orbit, as an axis, till the planes of the two orbits coincide. If their elements fulfil the condition (13),

$$(k\,l' - k'l)^2 + (k\,h' - k'h)^2 > (k' - k)^2,$$

the orbits will then intersect in two points. If, on this supposition, they do not intersect, it is evident that they cannot interlink; hence the preceding condition is one which must be fulfilled to render it possible for them to interlink. It is also necessary that, in the position supposed, these points should fall on opposite sides of the line of nodes. Now, in view of the small differences of mean distances, and considerable eccentricities of the asteroids, it cannot be regarded as at all singular that a large number of pairs should fulfil these conditions. As the orbits pass through their secular variations, some pairs which now interlink will cease to do so, and others which now do not interlink will do so. A change of this kind in some pair of orbits my be expected to occur in nearly every century. Hence the fact of interlinking does not indicate any relation among the asteroids other than their being found together in a continuous zone; and can throw no light whatever on the question of their origin.

In looking over a table of the elements of the asteroids, it is quite noticeable that the inclinations have a much wider range than the eccentricities. Thus, while there is but a single asteroid the eccentricity of which is less than .06, there are ten or twelve whose inclination is smaller than this quantity. Again, several of the inclinations considerably exceed the superior limit of the eccentricities. This may be seen by the following table, which exhibits the distribution in magnitude of the eccentricities and inclinations used in the preceding section: —

	e's	i's
From .00 to .05	1	8
.05 to .10	7	15
.10 to .15	20	16
.15 to .20	10	7
.20 to .25	14	4
.25 to .30	4	3
Above .30	1	4

It will also be observed, that there is a relative deficiency in the number of the abovementioned elements having small values. The latter fact is easily accounted for. In

the first place, if we consider the planet at the origin of its orbital motion, we see that, in order that its orbit may be *very nearly* circular, two independent improbable conditions must be fulfilled; — firstly, that the direction of its motion shall be *very nearly* at right angles to the line passing through the planet and the sun; secondly, that its velocity should be *very nearly* equal to $\frac{k}{\sqrt{r}}$, r representing the distance of the planet from the sun. If we regard the probabilities of these separate circumstances as small quantities of the first order, the probability of their concurrence will be a small quantity of the second order. The probability that the eccentricity does not exceed a small quantity, σ, will therefore be proportional to σ^2 so long as σ does not exceed a certain narrow limit.

The same reasoning can be applied to the inclinations. In order that the inclination of the orbit of a planet to a plane taken at random shall be very small, it is requisite both that the planet should be very near this plane, and that the line of direction of its motion should be very nearly in this plane.

To show the same result in a general form, we observe that h and l represent the negatives of the co-ordinates of the centre of the ellipse in which the planet is moving, when the mean distance of the planet is taken for unity. If now we project the positions of these points on the plane of the ecliptic, we might expect to find those near the sun distributed nearly at random. If we draw a circle with a small radius, ρ, another with a radius $2\,\rho$, &c., around the sun as a centre, and if the centres of the orbits are equally distributed, the space between the first and second circles will contain three times as many centres as the inner one, the space between the second and third five times as many, and so on. It will be perceived that there is really a deficiency of small eccentricities, and a superabundance of small inclinations, though neither irregularity is greater than what *might* result from chance deviations in distribution.

It has been suggested by an acute astronomer that the excess of small inclinations proceeds from the fact that observers generally look for asteroids very near the plane of the ecliptic. Considerable weight is given to this supposition by the circumstance that most of the asteroids have been near their node at the time of their discovery.

It seems highly probable, from this circumstance, that the mean inclination of the whole number of asteroids, known and unknown, is very much greater than that of the known ones. If so, the fact furnishes an additional argument against the hypothesis of explosion, since ζ must then be much greater than ξ.

VI.

Plantæ Wrightianæ e Cuba Orientali (Polypetalæ et Apetalæ), a

A. GRISEBACH.

(*Read August* 14, 1860.)

[The collection of dried plants of which Professor Grisebach has here commenced to give the determinations, with diagnoses of the new genera and species, was made by Mr. Charles Wright, in the eastern part of the island of Cuba, partly in the years 1856 and 1857, and partly in 1859 and the beginning of 1860. The specimens were mainly gathered in the high country and mountains behind Santiago de Cuba and Cobre (mostly within a moderate distance of *Filanthropia*, the hospitable country residence of George Bradford, Esq.), and especially in the elevated district back of Santa Catalina de Guantanamo, where the collector's principal station was *Monte Verde*, a coffee-plantation and residence of the most estimable and hospitable M. Lescaille; from which place as a centre Mr. Wright is still prosecuting and extending his herborizations. That the field is a rich and promising one, the great number of interesting and new species, enumerated in this and the following papers, abundantly show. In the distribution of these materials, the fullest set of the collection of 1856–57 was assigned to Professor Grisebach, in order that they might be studied by him, along with the materials of his Flora of the British West Indian Islands, now in course of publication. This set, enriched by the collector's valuable memoranda, was unfortunately lost on its way to Göttingen. As it could be only partially replaced, certain species of the first distribution have not been examined by Dr. Grisebach. Such of these species as I could name, more or less confidently, I have ventured to intercalate, always enclosing such additions, and other brief annotations I have had occasion to make, within brackets. When extracts from Mr. Wright's memoranda are given, they are placed within quotation-marks. Determinations of the *Monopetalæ*, &c. will follow.—Asa Gray.]

RANUNCULACEÆ.

Clematis dioica, L. (No. 1, 2.)

Clematis Flammulastrum, Griseb. (n. sp.): scandens, superne pubescens; foliis bis vel semel ternatisectis, segmentis parvis (6–2 lin. longis) ovato-lanceolatis integerrimis

glabrescentibus; corymbis 5-(3 – 1-) floris; floribus albis hermaphroditis; sepalis cuneato-oblongis expansis pubescentibus (4 – 6 lin. longis); antheris filamento multo brevioribus; ovariis plumosis. — Habitus *C. Flammulæ*, quæ sepalis juxta marginem glabris et antheris elongatis differt; antheris nostra cum *C. dioica*, L. convenit. (1561.)

MAGNOLIACEÆ.

Illicium parviflorum, Michx. — "In monte Loma del Gato dicto; Dec. Frutex 10-pedalis, petalis virido-luteis, staminibus rubris." (3.)

Talauma Plumieri, DC. "Arbor minor: sepala rubescentia: petala alba." (1100.)

ANONACEÆ.

Uvaria neglecta, Rich. — "Arbor mediocris, sylvicola, ramis strictis, floribus viridibus seu viridi-luteis." Petala velutina, oblonga, semipoll. longa. Specimina a descr. Rich. paullo recedunt foliis angustioribus obtusis, carpidiis monospermis. Semina ut in *U. Brasiliensi*, sed arillo destituta. (1103.)

Oxandra laurifolia, Rich. Cub. t. 8. "Flores albi: fructus viridis." (4, 489, 1101.)

Oxandra virgata, Rich. — Syn. *O. punctuata*, C. Wright, mscr. "Vulgo Lancewood. Arbor parva, foliis eximie punctatis, floribus albis." (1102.)

[Anona muricata, L. (5.)]

MENISPERMACEÆ.

Cocculus Domingensis, DC. (1105, florif.) [23, fructif.]

Cissampelos Pareira, L. (21.) Var. γ. *C. Caapeba*, L. (22.)

PAPAVERACEÆ.

[Bocconia frutescens, L. (6.)]

CRUCIFERÆ.

Nasturtium officinale, *R. Br.* (7.)

Nasturtium brevipes, Griseb.: annuum; caule brevi folia rosulata subæquante subaphyllo; foliis pinnatisectis, segmentis oblique subrotundis obtusilobis subæqualibus; floribus parvis pedicellatis; siliquis oblongo-linearibus pedicello quadruplo longioribus

(3 – 4 lin. longis); stigmate subsessili. — An *N. palustre*, ε *brevipes*, DC.? e Portorico. "In humidis ad vias prope Santa Catalina de Guantanamo, Jan. — Feb. Flores luteoli." (1562.)

CAPPARIDEÆ.

[Cleome polygama, L. (9.)] Capparis cynophallophora, L. (10.)

[Capparis Jamaicensis, Jacq. Syn. *C. emarginata*, Rich. (9ª.)]

[Capparis amygdalina, Lam. (9ᵇ.)] Moringa pterygosperma, Gærtn. (1588.)

BIXINEÆ.

Lunania Grayi, Griseb. (Pl. Amer. Trop. p. 26): foliis ellipticis obtusiusculis basi acutis et e basi ipsa trinerviis; pedicellis flore longioribus supra basin articulatis cum axi racemi puberulis; stigmate obtuso subintegro. (1110.) [Etiam 468? coll. 1856 – 7. "Arbor parva, gracilis, sylvicola."]

Lunania racemosa, Hook. "Arbor gracilis, 30 – 50-ped., floribus albidis." (1563.)

Xylosma infestum, Griseb. (n. sp.): spinis gracilibus patentissimis folio duplo brevioribus; foliis coriaceis glabris ovalibus obovatis oblongisque obtusiusculis subsessilibus superne obtuse serratis, serraturis paucis distantibus; floribus dioicis fasciculatis; pedicellis paucis brevibus flori æquilongis; calyce 5-partito, segmentis ciliolatis; staminibus 12 – 16 breviter exsertis; stylis 3; bacca ovata acutiuscula. — Frutex, "floribus viridulis, baccis rubris," a *H. nitido*, As. Gr. differt foliis rigidis, petiolo brevissimo, et spinis. "In præruptis prope villam Nouvelle Sophie." (1109.)

[Species sequentes duas imperfecte cognitas, a cl. Grisebach omissas, addo: —

[Xylosma buxifolium, A. Gr. (n. sp.): inerme, glabrum; foliis obovatis retusis rigide coriaceis integerrimis margine revolutis, venis fere obsoletis; floribus dioicis fasciculatis, masculis ignotis, fœmineis calyce 4 – 5-partito, segmentis angustis acutis eciliatis pedicellis multo brevioribus; ovario 4-ovulato, stigmate sessili bifido; bacca ovata. — "Prope Monte Verde, Dec. Frutex circa 10-pedalis." Folia cum petiolo brevi subpollicaria, obtusissima vel retusa, lævia sed opaca. Pedicelli pauci, $1\frac{1}{2} - 2\frac{1}{2}$ lin. longi. Calyx parvus, fere $\frac{1}{3}$ lin. longis. Discus annularis crassiusculus. Ovarium ovatum, placentis 2 biovulatis. Bacca 3 lin. longa, 1 – 2-sperma. (1465.)

[Xylosma schæfferioides, A. Gr. (n. sp.): inerme, glabrum; foliis obovato-cuneatis retusis subintegerrimis utrinque lineato-venosis; floribus dioicis fasciculatis, fœmineis ignotis, masculis calyce 4-partito, segmentis ovato-rotundis ciliatis; staminibus 12 – 16

longe exsertis pedicello duplo brevioribus. — " In scopulosis prope Monte Verde, Aprili. Arbor sat magna, trunco pedem diametro; flores flavidi." Folia pollicaria vel sesquipollicaria, obtusissima, sæpius retusa vel emarginata, nunc obliqua seu repando-undulata, supra nitidula, subtus pallida, utrinque venis gracilibus prominulis ascendentibus anastomosantibus, modo *Schæfferiæ* sed crebrioribus strictioribus, percursa: petiolo $1\frac{1}{2}$ – 2 lin. longo. Pedicelli masculi in fasciculo plures, 3 lin. longi. (1464.)]

Lætia ternstrœmioides, Griseb. (n. sp.): foliis coriaceis obovato-oblongis integerrimis obtusis vel emarginatis petiolatis glabris; corymbis pedunculatis axillaribus 3 – 7-floris; sepalis 7 – 8, interioribus (4 – 5) petalinis; fructu velutino ovoideo-globoso; placentis 3. — " Frutex 10-pedalis, seu arbor gracilis 15 – 20-pedalis, flores albi," habitu *Ternstrœmiæ*, affinis *L. Thamniæ*, Sw.: folia punctis et lineolis pellucidis notata. (1107.)

Thiodia lætioides, Griseb. Fl. Ind. Occ. 1, p. 22. " Arbor 40-pedalis; folia subcomplicata; flores viriduli." Placentæ in fructu demum trivalvi valde incrassatæ, " succo viscido "; semina arillata. (1108, fl., 1111. fr.)

Trilix (Prockia) crucis, Griseb. Pl. Carib. p. 17. (11.)

Valentinia ilicifolia, Sw. (12.)

Casearia sylvestris, Sw. (17.) Var. foliis subopacis. (1112.) [594 = 17. 595, inter 17 et 1112.]

Casearia stipularis, Vent. [Fruct. in coll. 1859 – 60 globosus, parvus.] (16.)

Casearia hirta, Sw. (15.) Vars. glabriores vel glabellæ. (13[a], 18.) [Huc forte no. 14.]

Guidonia spinescens, Griseb. Fl. Ind. Occ. 1, p. 24. (13, fl. in coll. I.; fr. in coll. II.)

[Samyda serrulata, L.? ex char. (19, fr.)]

VIOLACEÆ.

Hybanthus Havanensis, Jacq. (114.) Ionidium strictum, Vent. (20.)

POLYGALEÆ.

Polygala angustifolia, H. B. K. (112.)

PHLEBOTÆNIA, n. gen. Sepala 5, bina lateralia multo majora, colorata. Petala 3. Stamina monadelpha, 8: antheræ uniloculares, foramine rotundo introrso-terminali. Stylus lingulatus, labio stigmatis inferiori distante. Fructus ignotus. — Frutex glaber,

habitu *Polygalæ;* folia coriacea, venis rectis utrinque prominulis valde approximatis reticulato-striata; racemi breves axillares; pedicellis cum sinu rhacheos articulatis; bracteolis deciduis. — *A. Polygala* differt staminibus monadelphis et poro antheræ introrsum declivi.

Phlebotænia cuneata, Griseb. — Syn. *Polygala cuneata*, Griseb., in litt. olim. Folia rigida, cuneato-spathulata, apice emarginato-subtruncata, pollicaria, venis crassiusculis trabeculis distantibus invicem connexis. Racemi folium subæquantes, subsessiles, axi puberulo crassiusculo, sinubus denticulato; pedicellis 3 – 4 lin. longis florem subæquantibus. Sepala minora oblonga; alæ petala includentes, ovales, roseæ, illis quadruplo majores. — Prope urbem Santa Catalina de Guantanamo, 1856. (113.)

Badiera Domingensis, DC. (115.) Securidaca virgata, Sw. (1175.)

Securidaca Lamarckii, Griseb. Fl. Ind. Occ. 1, p. 30. (116.)

EUPHORBIACEÆ.

Tricera glomerata, Griseb. (n. sp.): foliis glaucescentibus elliptico-lanceolatis mucronato-acutiusculis (pollicem longis); floribus glomeratis; petiolo pedunculum brevissimum superante; calycis ♂ segmentis ovatis filamenta brevia multo superantibus; ovario e calyce ♀ exserto stylis longiori. — "Frutex 3 – 4-pedalis in scopulosis prope Nouvelle Sophie villam, Oct." (1676.)

Hieronyma clusioides, Griseb. — Syn. *Stilaginella*, Tul. (580.)

Savia sessiliflora, W. — Syn. *Phyllanthus laurifolius*, Rich. (587, 588, 1674.)

Savia erythroxyloides, Griseb. (n. sp.): ramulis glabris; foliis coriaceis obovatis v. ovalibus obtusis margine integerrimo revolutis glabris; ovario pubescente; stigmatibus brevibus reflexis bipartitis, segmentis crassiusculis. — "Frutex 6 – 10-pedalis, patens, in sylvis umbrosis pr. Monte Verde." — Eandem speciem pr. Matanzas fruticemque 4-pedalem dixit Rugel. A præcedente differt glabritie ramulorum, foliis rigidis basi attenuatis, capsula juniori pubescente. Flores dioici, in axillis glomerati. Calyx 5-partitus. Petala 5, in ♂ partim aut omnino abortiva. Discus minutus, 5-lobus. Stamina 5: rudimentum pistilli in ♂ 3-partitum vel minutum. Capsula tricocca; coccis dispermis, seminibus lævibus ecarunculatis. (♂ 1434, ♀ 1433.)

Drypetes glauca, Vahl. "Fructus ruber." (593.)

Cicca Antillana, Juss. Var. *α*, glaucescens, foliis subtus glaucis. [*Cicca scandens*, C. Wright in sched. "Climbing to the height of 30 to 50 feet, and spreading about among the branches of trees. La Perla, Monte Verde, Aug. 22."] (1437.)

Var. β. VIRENS; foliis concoloribus. "Frutex 5 – 10-pedalis; floribus viridi-flavis; fructu albido." (583, 584.)

Var. γ. PEDICELLARIS; foliis subtus glaucescentibus; baccæ pedicello longiori (3 – 4 lin. longo). "Arbor gracilis, 40-pedalis. Nouvelle Sophie, Oct. Semina cæruleo-purpurea." (584[a].)

PHYLLANTHUS NUTANS, Sw. (582, 1436, partim: specimina floribus majoribus.)

PHYLLANTHUS NIRURI, L. (590, [591,] 1675.)

PHYLLANTHUS (ANISONEMA) JAMAICENSIS, Griseb. Fl. Ind. Occ. 1, p. 34. (1436, partim,* specimina floribus minoribus.)

PHYLLANTHUS (ANISONEMA) MYRTILLOIDES, Griseb. (n. sp.): fruticosus; foliis obovato-rotundatis sæpe mucronatis glabris subtus glaucis breviter petiolatis; stipulis e basi lanceolata setaceis marcescentibus; pedicellis subsolitariis paucisve fasciculatis folium dimidium subæquantibus; floribus utriusque sexus mixtis; calycis segmentis 6 ovalibus; staminibus 3 exterioribus distinctis columnam æquantibus; columna centrali breviter trifida triandra; antheris breviter ovatis rima longitudinali dehiscentibus; stylo gracili ad medium trifida; stigmatibus breviter bidentatis; capsula globosa. — Habitus et magnitudo floris ut in *P. nutante.* Folia 10 – 4 lin. longa. Character sectionis *Anisonematis* columna integra aut breviter trifida amplificandus est. "Frutex diffusus, 6 – 9-pedalis. Fl. masc. albi, fœm. albidi. Prope Monte Verde, Dec." (1438.)

PHYLLANTHUS (ASTERANDRA) JUGLANDIFOLIUS, W. (586.)

PHYLLANTHI sp. aut var., specimina tantum ♀ indeterminata, sunt 1430, 1431, 1432: "arbusculæ."

JATROPHA HASTATA, Jacq. (575.) [JATROPHA GOSSYPIFOLIA, L. 576.]

[ALEURITES TRILOBA, Forst. Arbor Oceanica, nunc in Antillis spontanea. (577.)]

CROTON (CASCARILLA) STENOPHYLLUS, Griseb. (n. sp.): ramulis foliisque subtus flavescenti-tomentosis, his anguste linearibus acuminatis vel apice obtusiusculis integerrimis supra verruculoso-scabris basi eglandulosis in petiolum brevem attenuatis, venis crassiusculis obliquis supra sæpe impressis subtus prominulis; racemis terminalibus; seminibus oblongis. — "Frutex gracilis, 6 – 10-pedalis, prope Cobre et Nouvelle Sophie. Stamina alba." (560, 1669.)

CROTON (CASCARILLA) VIMINALIS, Griseb. (n. sp.): ramulis foliisque subtus luteo-lepidotis, his lineari-lanceolatis obtusiusculis integerrimis supra glabris basi eglandulosis

* [Magna pro parte.]

breviter petiolatis, venis crassiusculis transversis supra impressis subtus sæpe prominulis; racemis terminalibus; seminibus oblongis. — "Frutex gracilis, 6 – 12-pedalis, floribus albidis; pr. Monte Verde." (565.)

Croton (Cascarilla) discolor, W. "Prope Santa Catalina de Guantanamo." (564.)

Croton (Cascarilla) pachysepalus, Griseb. (n. sp.): ramulis scabro-pubescentibus; foliis parvis oblongo-lanceolatis obtusiusculis inæqualiter eroso-crenatis supra stellato-pubescentibus subtus tomentosis basi biglandulosis, glandulis subsessilibus, petiolo crassiusculo; racemis paucifloris in ramulo brevi terminalibus subsessilibus; calycis ♀ segmentis incrassatis. — Affinis *C. betulino*, Vahl. "In collibus prope Cobre; fruticosa." (559.)

Croton (Cascarilla) corylifolius, Lam. (566.)

Croton (Astræopsis) lucidus, L., var. glanduliferus, Vahl. (567.)

Croton (Lasiogyne) astroites, Ait.: forma depauperata, stylis minus divisis. (1670.)

Croton (Microcroton*) serpylloides, Griseb. (n. sp.): caulibus suffruticosis cæspitose decumbentibus filiformibus foliosis foliisque stellato-pubescentibus (v. demum glabrescentibus), his minutis orbicularibus integerrimis breviter petiolatis (2 – 1 lin. diam.); racemis paucifloris monoicis (v. abortu sexu distinctis) floribus ♂ superioribus 2 – 5, ♀ subsolitario longius pedicellato. (Eandem speciem prope Havanam leg. Greene, ej. coll. 7.) 569.)

[Croton sp. indeterminata. Specimina pauca, manca. (563.)]

[Croton (Geiseleria) glandulosus, L. (568.)]

Argythamnia candicans, Sw. Styli variant 2 – 3-partiti. (570.)

Adelia Ricinella, L. (581, 1435.)

Bernardia venosa, Griseb. (n. sp.): foliis lanceolatis ovatisque obtusiusculis margine calloso crenato-serratis supra glabris subtus in reticulo venarum prominulo ramulisque strigosis stellatoque-pubescentibus; amentis ♂ abbreviatis petiolo tomentoso brevioribus sessilibus, calyce tripartito; amentis ♀ breviter pedunculatis, calyce biseriatim 6-partito, stylis 3 – 4-partito-laceris. — Differt a *B. carpinifolia* foliis inter venas

* Sectio MICROCROTON. Calyx 5-partitus, valvaris. Petala in ♂ 5, in ♀ nulla. Stamina 5, petalis opposita. Ovarium glandulis 5 calyci oppositis cinctum: styli 4-partiti, apice involuti. Semina ovalia, subcompressa, rhaphe distincta, caruncula minuta. — Habitus *Codonocalycis;* folia exstipulata; racemuli terminales vel laterales.

secundarias prominulas glabratis, serraturis crebris callosis, pube rigente. Glandulæ in foliis subtus ocellatæ nunc sparsæ, nunc deficiunt. "Prope Monte Verde. Frutex ultra-orgyalis, floribus viridibus." (1425.)

Bernardia intermedia, Griseb. (n. sp.): foliis ovato-lanceolatis obtusiusculis margine calloso crenato-serratis supra scabriusculis subtus ramulisque molliter stellato-pubescentibus, reticulo venarum prominulo; amentis ♂ petiolum æquantibus subsessilibus, calyce tripartito; capsulis solitariis subsessilibus. — Venis secundariis subtus prominulis cum *B. venosa*, pube cum *B. carpinifolia*, Griseb. convenit. — "Frutex 8–12-pedalis, in scopulosis prope Nouvelle Sophie, Nov." (1671.)

Leucocroton (n. gen.) Wrightii, Griseb. Pl. Amer. Trop. p. 21. — Syn. *Croton Wrightii*, Griseb. olim. "Arbuscula, in sylvis densis prope Monte Verde; Maio 2, Junio 17." (561, 562, 1424.)

Alchornea latifolia, Sw. (579, 1668.) Acalypha alopecuroides, Jacq. (571.)

Acalypha reptans, Sw. (1426, 1672.)

[Acalypha, sp. foliis parvis. Var. præcedentis? (572.)]

Platygyne urens, Merc. — Syn. *Acanthocaulon pruriens*, Kl. (557.)

Tragia volubilis, L. (558, 1423.)

Sapium laurifolium, Griseb. Fl. Ind. Occ. 1, p. 49. (578.)

Sapium adenodon, Griseb. (n. sp.): foliis obovatis vel rhombeis obtusiuscule apiculatis basi exquisite cuneatis supra basin margine glandulifero regulariter glanduloso-serratis lævibus minutissime pellucido-punctatis, venis inconspicuis, petiolo eglanduloso; stipulis cordato-subrotundis; spicis ♂ axillaribus interruptis, calyce bifido, filamentis 2 e basi monadelpha divergentibus; pedunculis ♀ (in distinctis ramis) bracteiferis in florem terminalem abeuntibus, stylis abbreviatis. — "Frutex gracilis, orgyalis et ultra, in præruptis prope Monte Verde, Aug." (1428.)

DITTA, n. gen. Flores ♂ —, ♀ nudi, glomerati. Ovarium biloculare, loculis uniovulatis, ovulis pendulis: stigmata 4, sessilia, conica, nuda. Pericarpium subdrupaceum, endocarpiis binis lignosis rugosis ab epicarpio tenui et septo solutis. Semina . . . . . . — Frutex resinosus, habitu *Myricæ*, glaber: folia glandulis marginalibus *Sapii* instructa: flores sessiles in axillis congesti. — Genus *Bonaniæ*, Rich. Cub., a cl. Baillon ad *Sapium* reductæ, affine videtur florem situ: a stylis in duplicem conum ad basin divisis nominantur.

Ditta myricoides, Griseb. — Folia approximata, lanceolata, obtusiuscula, superne

repando-denticulata, basi in petiolum brevem attenuata, bi-sesquipollicaria: stipulæ nullæ vel sub resina effluente inconspicua. Ovaria bracteis subrotundis (v. calycis rudimento?) distincta, lineam longa, 5 vel pauciora in plerisque axillis; stigmatibus margine protrusis divergentibus obtusiusculis. Drupa subglobosa 2 lin. diametro. "Prope Monte Verde, Jan. 3. Frutex vel arbuscula." (1429.)

[EXCŒCARIA (GYMNANTHES) LUCIDA, Sw. (585, fructif.)]

EXCŒCARIA (SEBASTIANIA) PALLENS, Griseb. (n. sp.): glabra; foliis coriaceis lanceolatis supra basin remote serrulatis vel subintegris basi attenuata supra canaliculata a petiolo distinctis; amentis androgynis folio duplo brevioribus interruptis breviter pedunculatis; bracteis ♂ margine incurvo glandulosis trifloris; floribus tri-(2-4-)andris, centrali squamulis 4 angustis stipato, antheris breviter exsertis filamentum subæquantibus; floribus ♀ 1-2 in basi amenti sessilibus aliisque ex distinctis axillis pedicellatis solitariis; stylo tripartito; capsulæ valvis coriaceis apice cohærentibus; seminibus ovoideo-globosis, caruncula obsoleta.—"In scopulosis prope Monte Verde. Frutex patens, 6-10-pedalis." (1427.)

EXCŒCARIA ERYTHROSPERMA, Griseb. (n. sp.): glabra; foliis lanceolatis vel elliptico-lanceolatis supra basin remotiuscule glanduloso-serrulatis; amentis —; seminibus semiovoideis facie interiori convexis arillo rubro inclusis, caruncula obsoleta.—Similis *E. lucidæ*, semine rubro et caruncula evanida distincta.—"In monte La Guinea, Dec. Frutex 10-15-pedalis." (1673.)

PEDILANTHUS LINEARIFOLIUS, Griseb. (n. sp.): foliis elongato-linearibus basi attenuatis apice mucronatis (3-4-pollicaribus, lin. 2 fere latis); pedunculis umbellatis vel cymosis; bracteis 2 ovatis involucrum ante anthesin includentibus; involucro æquali apice truncato uniglanduloso, glandula maxima rotundata, appendice dorsali foveata crasse marginata labiiformi, margine apice emarginato inferne in calcar brevissimum apice subdidymum producto; ovario exserto; capsula lævi.—Sectionem generis involucro truncato distinctam format magisque quam genera Klotzschiana a cæteris recedit.—"In scopulosis ad Nouvelle Sophie, Nov. Fruticosa, 6-9-pedalis, bracteis involucribusque rubellis." (1677.)

EUPHORBIA DIOICA, H.B.K. (547.) EUPHORBIA PROSTRATA, Ait. (548, 549.)

EUPHORBIA PILULIFERA, L. (550, 551.) EUPHORBIA HYPERICIFOLIA, L. (552, 1422.)

EUPHORBIA HETEROPHYLLA, L. var. PRUNIFOLIA, Jacq. (554.)

EUPHORBIA PUNICEA, Ait. [Semina globosa, lævia, opaca, albida-variegata, caruncula haud manifesta.] (556.)

EUPHORBIA aff. *E. heterophyllæ*, L. in DC. Prodromo a cl. Boissier mox edenda. (555.)

EUPHORBIA MONANTHA, C. Wright, mscr., a cl. Boissier describenda. "Inter saxa in rivis desiccatis prope Monte Verde, Junio. Radix tuberosa." (1421.)

[EUPHORBIA, sp. aphylla, articulata, siccitate ramulis acutissime pluricostatis. (553.)]

CARYOPHYLLEÆ.

DRYMARIA CORDATA, W. var. DIANDRA. (24.)

[CYPSELEA HUMIFUSA, Turp. (596.)]

MOLLUGO NUDICAULIS, Lam. (25.)

TALINUM PATENS, W. (26.)

PHYTOLACCEÆ.

PHYTOLACCA OCTANDRA, L. (1392.)

PHYTOLACCA ICOSANDRA, L. (470.)

RIVINA LÆVIS, L. et vars. (469.)

RIVINA OCTANDRA, L. (471.)

PETIVERIA ALLIACEA, L. (1391.)

AMARANTACEÆ.

IRESINE CELOSIOIDES, Linn. (474.)

[IRESINE ELATIOR, Rich. (473.)]

[IRESINE (PHILOXERUS) SERPYLLIFOLIA, Moq. ex char. (475.)]

[CHAMISSOA ALTISSIMA, H.B.K.) (472.)]

WŒHLERIA SERPYLLIFOLIA, Griseb., Pl. Amer. Trop. p. 10.* "Prope Monte Verde in fissuris rupium." (1396.)

NYCTAGINEÆ.

BŒRHAAVIA SCANDENS, L. (467.)

PISONIA NIGRICANS, Sw.! (non alior.) Syn. *P. pedicellaris*, Griseb. olim. (465 pro parte, 466.)

[PISONIA ACULEATA, L. (465 pro parte, coll. 1856–7, 1859–60, fruct. glandulis pedicellatis ornato.)]

* "WŒHLERIA, n. gen. Calyx tribracteolatus, quadrisepalus, sepalis subæqualibus lana destitutis. Stamen unicum, hypogynum, sepalorum alteri interiorum oppositum; filamento filiformi basi minute bidentato; anthera subglobosa uniloculari. Ovarium uniovulatum: stigmata 2, filiformia, sessilia. Pericarpium utriculare. — Herba minuta, filiformis, diffusa, radicans, glabra, habitu *Illecebri* v. *Lithophilæ;* folia opposita, subrotunda, petiolata; capitula in ramulis terminalia, alba, minuta, demum oblongata, pedicellata; sepalis scariosis bracteas multo superantibus." Griseb. l. c.

Pisonia obtusata, Sw., var. rufescens: foliis junioribus subtus cymisque rufo-tomentosis. — "Arbor sat magna, floribus viridulis." (464.)

MALVACEÆ.

Malvastrum spicatum, As. Gr. Bot. Pacif. Expl. Exped. 1, p. 147. (27.)

Sida carpinifolia, L. (1115.) Var. brevicuspidata, Griseb. Fl. W. Ind. (1565.)

Sida glomerata, Cav. (1566.)

Sida Jamaicensis, L. (29.)

Sida rhombifolia, L. (1116.)

[Sida spinosa, L. (28.)]

Sida urens, L. (1564, 30[a].)

Sida hederifolia, Cav. (1567.)

Sida paniculata, L. (1569.)

Sida pyramidata, Cav. (1570.)

[Sida ulmifolia, Cav., forma subglabra. (30.)]

Sida nervosa, DC. Lusus pedicellis infra medium articulatis. (1568.)

Sida cordifolia, L., var. S. althæifolia, Sw. (31.)

[Abutilon (Wissadula) periplocifolium, Don. (32.)]

Abutilon (Belœre) confertiflorum, Rich. Cub. (1572.)

Abutilon (Belœre) permolle, Don. (1571.)

[Malachra capitata, L. var. alceifolia, Griseb. (36.)]

Malachra radiata, L. (35, 1573.)

Urena sinuata, L. (1114.)

Pavonia typhaleoides, H.B.K. Syn. *P. Pseudotyphalea*, Griseb. olim. Arista media quandoque breviori a forma vulgari recedit. "Flores albi." (33.)

Pavonia Spinifex, Cav. (34.) Var. involucello calycem excedente 6–10-phyllo. (1113.)

Hibiscus (Ketmia) cryptocarpus, Rich. Cub. "Fruticosus, ultraorgyalis, corolla atro-rubra." (1575.)

Hibiscus (Bombicella) phœniceus, Jacq. non. Cav. (1574.)

Thespesia populnea, Cav. (1576.)

Paritium tiliaceum, A. Juss. (37.)

BOMBACEÆ.

CARPODIPTERA, n. gen. — Calyx bi–trifidus, persistens, lobis subinæqualibus valvatis. Petala 5, hypogyna, sinistrorsum contorta, late unguiculata, bina majora. Stamina

16 – 13, hypogyna, basi monadelpha; filamentis inæqualibus; antheris unilocularibus terminalibus reniformibus seu obliquis sursum vel introrsum dehiscentibus. Ovarium liberum, sessile, biloculare, loculis uniovulatis; ovulis supra medium loculum affixis pendulis: stigmata 2, sessilia, effigurata, crenato-multilobulata. Samara bilocularis, carpidiis utrinque latere (ad modum *Hireæ*) alatis, alis 4 divergentibus. Semina compressa, orbicularia, apicibus comata; testa coriacea. — Arbor, ramulis petiolisque stellato-puberulis; foliis glabrescentibus subpenninerviis ovato-oblongis acuminatis basi 5-nervi minute subcordatis integerrimis; stipulis deciduis; cymis pedunculatis corymbiformibus axillaribus; calyce stellato-tomentoso; corolla rubra [seu "pallide purpurea"] glabra. — Genus ovulis pendulis heteroclitum, *Myrodiæ* paullisper affine.

Carpodiptera Cubensis, Griseb. — Folia 2 – 3-pollicaria, cymas duplo superantia, petiolo 6 – 4 lin. longo. Calyx subglobosus, lineam latus, petalis majoribus duplo superatus. Stamina inclusa, ovarium æquantia. Carpidia samaræ connexa, calycem duplo superantia, alis semi-obovatis stellato-expansis 8 lin. longis. "Arbor 30 – 50-pedalis, in sylvis prope Santa Catalina, in declivibus prope villam Nouvelle Sophie dictam, Aug. et Oct." (1117.)

Ochroma Lagopus, Sw. (38.)

BUETTNERIACEÆ.

Guazuma tomentosa, H.B.K. (47.)

Buettneria microphylla, L. (41.)

Melochia tomentosa, L. (40.)

[Melochia nodiflora, Sw. (39.)]

[Waltheria Americana, L. (42.)]

TILIACEÆ.

Triumfetta semitriloba, L. (43.)

Triumfetta grossularifolia, Rich. (44.)

Corchorus siliquosus, L. (45.)

Muntingia Calabura, L. [Ex cl. Wright "Placentæ axiles inter se liberæ."] (46.)

Sloanea curatellifolia, Griseb. (n. sp.): ramulis petiolis stipulisque puberulis; foliis ovali-oblongis (6 – 8 unc. longis) sinuato-denticulatis glabris, petiolo apice tumido (8 – 12 lin. longo), stipulis elongato-acuminatis deciduis; pedicellis lateralibus; calyce persistente 5-partito velutino, segmentis ovatis vel ovato-subrotundis ovario brevioribus; staminibus —; stylo trifido, ramis filiformibus acutis erectis; capsula ovoidea setis ejus diametrum transversalem superantibus pubescentibus rectiusculis. — "Arbor excelsa, *Achiote* incolarum, in sylvis prope Monte Verde, Jan." (1118.)

SLOANEA AMYGDALINA, Griseb. (n. sp.): ramulis puberulis glabrescentibus; foliis parvis (sesqui–bipollicaribus) obovato-oblongis leviter emarginatis superne subcrenato-repandis glabris, petiolo æquali (4–2 lin. longo); stipulis deciduis; pedunculis axillaribus bi–trifidis; pedicellis æquilongis; calyce 4-partito intus velutino, segmentis deltoideis; staminibus pubescentibus breviter exsertis, filamentis brevissimis, antheris oblongo-linearibus infra mucronem terminalem subrecurvum loculo triplo breviorem foramine ovali dehiscentibus; stylo brevi simplici apice incurvo obtusiusculo; ovario setuloso; capsula —. Affinis *S. quadrivalvi*, Seem., "per exsiccationem amygdalas amaras spirat." [Capsula globosa, quadrivalvis, setulis brevissimis creberrime vestita.] "Arbor magna, trunco basi in laminis latis excurrente. Prope Monte Verde in sylvis; Junio." (1119.)

RHAMNEÆ.

COLUBRINA FERRUGINOSA, Brongn. (1139.) COLUBRINA RECLINATA, Brongn. (76.)

ZIZYPHUS HAVANENSIS, H.B.K. Specim. fructif. (1298.)

GOUANIA TOMENTOSA, Jacq. var. PUBESCENS. (75.)

AMPELIDEÆ.

CISSUS SICYOIDES, L. (74.) Et forma parvifolia. (1136.)

CISSUS TRIFOLIATA, L.: α, foliolis pellucido-punctatis ovatis acutis superne remote incumbenti-serratis. (72.) Forma floribus luteo-rubris. (72, partim.) [Forma foliolis promisse acuminatis, 70.]

Var. β. CAUSTICA (*C. caustica*, Tuss.): foliolis pellucido-punctatis cuneato-ellipticis obtusiusculis superne remote serratis. "Flores coccinei." (1137.)

Var. γ. INTERMEDIA, (*C. intermedia*, Rich.): foliolis opacis cuneato-ellipticis obtusis superne remote denticulato-serratis vel subintegerrimis; pedicellis hirsutis vel glabrescentibus; bacca obovata. (71, 73.)

Var. δ. OBOVATA (*C. obovata*, Vahl): foliolis demum opacis spathulatis obtusis integerrimis vel repando-paucidenticulatis. (1138.)

VITIS CARIBÆA, DC. (69, specim. florif. & fructif.)

TERNSTRŒMIACEÆ.

TERNSTRŒMIA OBOVALIS, Rich. (*T. meridionalis*, Swartz, etc. non W.) "Corolla alba." (1125.)

TERNSTRŒMIA ELLIPTICA, Sw. (*T. meridionalis*, W. non Sw. *T. peduncularis*, DC.) Ludit foliis emarginatis et obtusis. (1577.)

TERNSTRŒMIA CLUSIIFOLIA, H.B.K. "Corolla pallide lutea." (1124.)

CLEYERA THEOIDES, Planch.; Griseb. Fl. Ind. Occ. 1, p. 103. (1126, 1145.)

FREZIERA HIRSUTA, Sw.; a forma Caribæa recedens petiolo longiori et serraturis folii minoribus. (49.)

LAPLACEA WRIGHTII, Griseb. (n. sp.): ramulis glabris; foliis spathulatis apice emarginatis integerrimis subsessilibus glabris, nervo mediano subtus glabrato; sepalis sericeo-velutinis; capsula 5-angulari lineari-oblonga, loculis trispermis. — Proxima *L. Curtyanæ*, Rich., foliis glabris emarginatis distincta. "In sylvis prope Monte Verde. Arbor gracilis, floribus albis, antheris extrorsis." (48.)

OCHNACEÆ.

GOMPHIA ALTERNIFOLIA, Rich. Drupæ obovatæ, "læte cyaneæ." (58.)

GOMPHIA REVOLUTA, C. Wright, mscr. (n. sp.): foliis parvis elliptico-oblongis spathulatisque obtusis integerrimis margine revolutis breviter petiolatis, venis tenuissimis; panicula laxa corymbosa; pedicellis gemmam ovatam obtusam duplo superantibus; sepalis ovali-oblongis corolla paullo brevioribus; antheris lævibus; drupis subglobosis basi contractis. — Prope Monte Verde. (1128.)

GUTTIFERÆ.

TOVOMITA CLUSIOIDES, Griseb. (n. sp.): foliis obovatis obtusis integerrimis basi obtusiusculis (2 – 3½ poll. longis), venis primariis rectis crassiusculis utrinque prominulis, petiolo brevi crasso; cyma terminali pauciflora foliis superata, pedicellis tetragonis; sepalis 2 deciduis; petalis 6; staminibus plurimis; filamentis superne dilatatis; antheræ loculis breviter oblongis lateralibus. — Habitu accedit ad *Clusiam venosam* et *T. havetioidem*. Flores "albi," fœm. ignoti. — "In pinetis prope Monte Verde. Arbuscula." (1121.)

CLUSIA ROSEA, L. (50.) CLUSIA ALBA, L. (51.) CLUSIA FLAVA, L. (52.)

RHEEDIA, Griseb. n. gen. Flores hermaphroditi.* Sepala 2, persistentia. Petala 4, imbricativa. Stamina plurima, infra gynophorum inserta: antheræ minutæ, globosæ,

[* Flores non revera hermaphroditi, sed in spec. coll. 1856 – 7 ovarii abortu steriles, staminibus validioribus; in coll. 1859 fertiles, subhermaphroditi, staminibus minoribus. Folia pleraque angustiora, lanceolata.]

introrsæ. Ovarium gynophoro mamillari suffultum, 4-loculare, loculis uniovulatis: stigma late depressum, convexum, obsolete 4 lobum, sessile. Pericarpium drupaceum. Testa lignosa. — Frutex habitu florum *Berberidis*, foliorum *Rusci*, ramis triquetris vel tetragonis; folia parva, rigida, mucronato-aristata, opposita vel terna. Pedicelli axillares solitarii, exserti. — Genus *Mammeæ* affine, gynophoro et flore hermaphrodito ab ejus sectione *Rheediandra* (*Rheedia*, L.) distinctum, habitu inter *Clusiaceas* peculiare, cui nomen reductione *Rheediæ* Linnæanæ e systemate expulsum redditur.

Rheedia ruscifolia, Griseb. — Folia subpollicaria, lanceolata-oblonga, rigida, marginata, venis primariis crassiusculis, petiolo brevi incrassato. Pedicelli folia vulgo duplo superantes. Petala ($2\frac{1}{2}$ lin. diametro) subrotunda, calyce plus duplo longiora. Drupa ovoidea. — "In pinetis prope Monte Verde. Arbuscula, ramis horizontalibus, succo resinoso flavo, floribus pallide luteis. Ovarium triloculare." (53.)

Calophyllum Calaba, Jacq. (1122.)

MARCGRAAVIACEÆ.

Marcgraavia umbellata, L. (54, 1123.)

HYPERICACEÆ.

Marila racemosa, Sw. (1120.)

ERYTHROXYLEÆ.

Erythroxylum obtusum, DC. (86, 1149.)

MALPIGHIACEÆ.

Byrsonima spicata, Rich. (82.) Byrsonima lucida, Rich. (1150, 84[a], fruct.)

Byrsonima biflora, Griseb. (n. sp.): fruticosa; foliis spathulatis obovatisque in petiolum brevem angustatis margine revolutis glabris supra lucidis venis teneribus remotiusculis; racemis in ramulo terminalibus in corymbum bi-pauciflorum contractis, pedicellis folio demum brevioribus, bracteis ovato-lanceolatis subæqualibus; petalis rubris; antheræ loculis glabris connectivo apice subrecurvo subæqualibus; ovario glabro. — Affinis *B. lucidæ*, inflorescentia in genere singularis. (84.)

Bunchosia media, DC. (89.) [No. 87 est eadem fructifera; 88, florifera.]

Malpighia glabra, L. (90.) [Malpighia punicifolia, L. (85, fr.)]

MALPIGHIA OXYCOCCA, Griseb. Fl. Ind. Occ. 1, p. 117. Drupa obtusangula. (83, 1583.)

MALPIGHIA CNIDA, Spreng. (100.)

[MALPIGHIA COCCIGERA, L.? foliis anguste oblongis. (99.)]

STIGMAPHYLLON MICROPHYLLUM, Griseb. (n. sp.): foliis parvis (5–8 lin. longis) oblongis utrinque rotundatis apice mucronulatis supra glabris subtus ramulisque puberulis, glandulis 2 infra apicem petioli collocatis stipitatis; pedicellis infra medium articulatis et bibracteolatis; stigmatibus 2–1 foliaceis, binis aut tertio compresso-truncato. — Fructus ignotus. (93.)

STIGMAPHYLLON SAGRÆANUM, Juss. (97.)

BANISTERIA PAUCIFLORA, H.B.K. (95, 1584.)

HETEROPTERIS LAURIFOLIA, Juss. (92.)

TRIOPTERIS RIGIDA, Sw. — Glandulæ in basi folii adsunt, sed evanescunt. (96.)

[TETRAPTERIS sp. indeterm. 94. Malpighiacea indeterminata, fruct. ignot. 98.]

SAPINDACEÆ.

SERJANIA LUCIDA, Schum. "Flores coccineo-rosei." (109.)

SERJANIA DIVARICATA, Sw.: forma foliolis versus apicem pauciserratis, serraturis obtusis. "Caulis scandens, sectus succum lacteum effundit. Flores albi." (1587.)

SERJANIA CRENATA, Griseb. (n. sp.): foliis biternatis pellucido-punctatis ramulisque glabratis, foliolis ellipticis vel elliptico-oblongis grosse crenatis, petiolo communi anguste marginato; racemis compositis; samara glabra, ala semi-obcordata basi ad medium carpidium usque producta. — "Ad Monte Verde, Nouvelle Sophie, etc. Alte scandens; flores albi." (108[a].)

PAULLINIA CURASSAVICA, Jacq., Sw. (107, bis, 110, 1172.)

PAULLINIA PINNATA, L. (104, 1171.)

CUPANIA GLABRA, Sw. "Arbor excelsa, gracilis." (1165, 1586.) [No. 105 est eadem, fructu maturo.]

CUPANIA AMERICANA, L. (108, 1166.)

CUPANIA TRACHYCARPA, Griseb. (n. sp.): ramulis hispidulis glabratis; foliolis abruptim 8-jugis suboppositis oblongo-lanceolatis acuminatis integerrimis glabris, venis ten-

uibus 6 – 10-jugis; racemis simplicibus axillaribus; capsula globosa ecarinata subsessili scabro-tomentosa; semine subgloboso-trigono arillo involuto. — Flos ignotus. [Folia interdum impari-pinnata; capsula glabrescens. (103.)

Blighia sapida, Kœn. "Culta." (1170.)

Ratonia apetala, Griseb. Fl. Ind. Occ. 1, p. 126. [Polygamo-dioica: adsunt in fl. masc. "petala minuta, albida," crassa, discum vix superantia. Folia sæpissime disjuncta.] (1604, fl. masc., 1151, fr.)

Schmidelia Cominia, Sw. (106, 1161.) Schmidelia rigida, Sw. (1164.)

Schmidelia occidentalis, Sw. (102, 1162, 1163.)

[Thouinia tomentosa, DC. ex char. (106, bis.)]

Thouinia nervosa, Griseb. Syn. *Schmidelia nervosa*, Rich. Cub. t. 29. (1173.)

Melicocca bijuga, L. (1167, 1168.) Hypelate paniculata, Camb. (1169.)

STAPHYLEACEÆ.

Turpinia occidentalis, Don. (111, 1174.)

MELIACEÆ.

[Trichilia spondioides, Sw. (101.)]

Moschoxylum trachyanthum, Griseb. (n. sp.): ramulis petiolisque strigilloso-pubescentibus; foliolis parvis rigidis 9 – 7 ovalibus rotundatis glabratis utrinque reticulato-venosis; paniculis racemiformibus folio superatis; pedunculis partialibus brevibus in corymbulos subtrifloros divisis; corolla extus strigillosa 5-partita calycem triplo superante, segmentis oblongis obtusiusculis patentibus; ovario sericeo-tomentoso. — Prope Monte Verde. Sept. (1134.)

Guarea trichilioides, L. (63, florif., 107, fruct.)

Swietenia Mahagoni, L. (1153.)

Cedrela odorata, L. (1152, florif., 1582, fruct.)

AURANTIACEÆ.

Citrus Aurantium, L. "Bitter Orange: in sylvis ubique." (1127.)

OXALIDEÆ.

Oxalis violacea, L. "In fissuris rupium prope Josephina, Nov. Flores albi seu leviter purpurei." (1579.)

[Oxalis corniculata, L. (55.) Var. microphylla? (56.)]

ZYGOPHYLLEÆ.

[Guaiacum officinale, L. (57.)]

RUTACEÆ.

Ravenia spectabilis, Planch. — Syn. *Lemonia spectabilis*, Lindl. (61.)

Raputia heterophylla, DC. — Ad *Galipeam* videtur reducenda. Specimina exstant tantum fructifera, foliis trifoliolatis et simplicibus, oppositis et sparsis variantia, racemo simplici, carpidiis a dorso arcuatim costulatis. [Reperi flores nonnullos, corolla 5-petala, stellatim patentissima, atro-rubra, æstivatione valvata: discus, genitalia, semen, embryo, etc. omnino *Pilocarpi*. Ergo Pilocarpus heterophyllus. Ex cl. Wright "frutex 10–15-pedalis; prope Monte Verde, coll. Dec. 25."] (1129.)

Tobinia emarginata, Desv. — Syn. *Zanthoxylum coriaceum*, Rich. Cub. t. 34. (62.)

Zanthoxylum Clava-Herculis, L. — Syn. *Z. Caribæum*, Lam. (1132, 1132[a].)

Zanthoxylum aromaticum, W. (1131.)

Fagara dumosa, Griseb. — Syn. *Zanthoxylum dumosum*, Rich. Cub. Proxima *F. microphyllæ*, Desf.; differt foliolis tuberculo basilari destitutis ternatis vel abortu binatis, et petiolo spathulato-oblongo apice subtus aculeifero. (1605.)

Brunellia comocladifolia, H.B.K. (60, 1133.)

Picramnia pentandra, Sw. (64, 65.)

ERICEÆ.

Clethra byrsonimoides, Griseb. (n. sp.): ramulis petiolis axibusque racemi rufo-villosis; foliis obovato-oblongis integerrimis vel superne serrulatis glabris, venis 6–8-jugis; racemis simplicibus vel in apice rami aggregatis; bracteis lanceolatis deciduis pedicello refracto brevioribus; petalis apice erosis calycem tomentosum paullo superantibus; antheris obovatis basi breviter mucronatis, loculis lato poro dehiscentibus; stylo incluso. — "In Monte Lomo del Gato dicto, Dec. Arbor gracilis, floribus albis." (343.)

[Andromeda (Lyonia) Jamaicensis, Sw. var.? In declivibus prope Cobre, Jan. (1635.)]

Vaccinium (Vitis-idæa) Cubense, Griseb. (n. sp.): ramulis glabriusculis; foliis obovatis obsolete mucronulatis margine cartilagineo integerrimis vel obsolete serrulatis glabris; pedicellis axillaribus solitariis flore longioribus supra basin bibracteolatis; calycis limbo 5-partito, segmentis deltoideis; corolla ovata glabra, lobis patentibus tubo duplo brevioribus; genitalibus inclusis; antheris e dorso biaristatis, aristis tubulo triplo brevioribus. — "Ad Lomo del Gato et Monte Verde. Arbuscula, corolla saturate rubra." (342.)

CYRILLEÆ.

Cyrilla Antillana, Michx. (1320.)

Purdiæa stenopetala, Griseb. (Pl. Amer. Trop. p. 45): sepalis exterioribus 3 ovato-oblongis obtusis corollam longitudine æquantibus latitudine excedentibus, 2 interioribus minoribus ovato-lanceolatis acutis corollam dimidiam superantibus; petalis oblongis mucronato-obtusiusculis. Ceterum *P. nutanti* simillima. — "Ad Lomo del Gato et Monte Verde." (341.)

CELASTRINEÆ.

Schæfferia frutescens, Jacq. (77.)

Elæodendron attenuatum, Rich. (1144.) Forma foliis superne serrulatis. (1585.)

Myginda latifolia, Sw., var. Recedit ramis teretiusculis et foliis vulgo angustioribus. "Flores albi. Frutex 10 – 15-pedalis et ultra. In monte La Guinea dicto, Dec." (81.)

["Euonymus cuneifolius, n. sp. In monte La Guinea et in pinetis prope Monte Verde; Aug. florif., Dec. fructif. Arbuscula; flores albi." C. Wright mscr. — Folia fere exacte angustioris formæ præcedentis, sæpe paululum crassa basi longiusque attenuata; inflorescentia, etc. simillima. Ovarium bilobum. Fructus bi- vel abortu uni-follicularis; pericarpio coriaceo lævi oblongo-obovato subcurvato intus dehiscente. Semen unicum, erectum, loculo conforme, arillo cerino cupulæformi semitectum. (1140.)

ILICINEÆ.

Ilex montana, Griseb. — Syn. *Prinos montanus* et *P. sideroxyloides*, Sw. (78, 79.)

Ilex dioica, Griseb. — Syn. *Prinos dioica*, Vahl. Forma foliis basi attenuatis, bacca 4-pyrena; flores ignoti. (1143.)

ILEX CELASTROIDES, H.B.K. ex diagn. (1141.)

ILEX REPANDA, Griseb. (n. sp.): glabra; foliis (2 – $2\frac{1}{2}$-pollic.) obovatis apice emarginato-rotundatis supra medium remote obtuseque serrulatis vel subintegris supra lucidis subtus venosis pallidis breviter petiolatis; floribus fasciculatis; pedicellis baccam subæquantibus petiolo longioribus; calyce 4-lobo; bacca obovata (2 lin. longa) lævi 4-pyrena. — "Arbor parvula, ramis virgatis. Prope La Perla, May 28." (1142.)

HIPPOCRATEACEÆ.

HIPPOCRATEA SCANDENS, Jacq. (1147.)

HIPPOCRATEA OVATA, Lam. (80.) Var. paniculis contractis folio multo brevioribus. (1148.)

ANTHODON VERRUCOSUS, Griseb. (n. sp.): glaber; foliis crassis ovali-oblongis utrinque rotundatis integerrimis politis (sesqui – bipollicaribus), venis sæpe inconspicuis, petiolo brevi crassiusculo demum annulatim verrucoso; pedicellis brevibus solitariis vel fasciculatis; flore majusculo (4 lin. diam.); petalis obovato-orbicularibus integerrimis calycis lobos breviter rotundatos multo excedentibus; staminibus intra discum insertis. — Syn. *Salacia verrucosa*, C. Wright mscr.; sed ex antheris apice transversim dehiscentibus loculis confluis non *Salacia*. — "In sylvis umbrosis prope Monte Verde, scandens; Aug. Flores dilute miniati." (1146.)

[CHAILLETIÆ spec. *C. cubensi* proxima est no. 1299. Flores desiderantur.]

URTICACEÆ.

CELTIS TRINERVIA, Lam. "Folio pellucido-punctulata." (1441.)

CELTIS ACULEATA, Sw. (524 & 526, pr. parte, fructif.)

SPONIA MICRANTHA, Desc. (525.)

SPONIA LAMARCKIANA, Desc. "Arbor 20-pedalis et frutex orgyalis." (1442.)

FICUS (UROSTIGMA) SUFFOCANS, Herb. Banks. "Arbor excelsa." (543, 1445.)

FICUS (UROSTIGMA) CRASSINERVIA, Desf. (541.)

FICUS (UROSTIGMA) TRIGONATA, L. "Arbor magna, fructibus læte rubris." (1444, 1685.)

FICUS (UROSTIGMA) LÆVIGATA, Vahl. (544, 1684.)

FICUS (UROSTIGMA) LENTIGINOSA, Vahl. (1686.)

FICUS (UROSTIGMA) DIMIDIATA, Griseb. Fl. Ind. Occ. p. 151. "Arbor parva patens, vel majuscula, fructibus miniatis." (542, 1683.)

FICUS (UROSTIGMA) ELLIPTICA, H.B.K. (= Fendl. coll. Venezuel. no. 1763.) (1443.)

FICUS (UROSTIGMA) PERTUSA, L. (545.)

CECROPIA OBTUSA, Trec. "Arbor excelsis, sylvicola." (1440.)

TROPHIS AMERICANA, L. (589, 592.)

MACLURA TINCTORIA, Don. (1439.)

DORSTENIA TUBEROSA, C. Wright, mscr. (n. sp.): acaulis; foliis (6 – 12 lin. diam.) cordato-orbicularibus repando-integerrimis glabrescentibus, nervis subtus petiolisque pilosiusculis; receptaculis cyathiformi-orbicularibus denticulatis peltatis; pedunculo petiolo (pollicari) superato. — "Ad rivos prope Monte Verde; Julio. Planta tenella, violæfolia, rhizomate tuberifero." (1446.)

DORSTENIA CRENULATA, C. Wright, mscr. (n. sp.): acaulis; foliis (6 – 8 lin. diam.) cordato-subrotundis repando-crenatis subtus margineque pilosiusculis; receptaculis cyathiformibus subintegris peltatis; pedunculo petiolum (1 – 2-pollic.) subæquante vel superante. — "Ad rivos umbrosos prope Monte Verde; Sept. Rhizoma filiformis, ut in præcedente tuberifera." (1447.)

FLEURYA UMBELLATA, Wedd. "In sylvis opacissimis." (1453.)

URERA BACCIFERA, Gaud. (527.)

PILEA MICROPHYLLA, Liebm. (538, 1452.) Var. HERNIARIOIDES, Lindl. (536, 1456, 1679.) Var. PEREGRINA, Griseb.: foliis orbicularibus (semilineam diam.) subciliatis, rhaphidibus obsoletis. (1458.)

PILEA HETERONEMA, Griseb. (n. sp.): diffusa, ramosissima, minutifolia; foliis rhombeo-cuneatis acutiusculis integerrimis triplinerviis subciliolatis; majoribus (3 lin. longis) in jugo longius petiolatis, rhaphidibus in utraque pagina linearibus vagis; floribus glomeratis in axilla subsessilibus. — In sylvis umbrosis et juxta rivulos prope Monte Verde. Caulis 1 – 4-pedalis." (537.)

PILEA GNIDIOIDES, Griseb. (n. sp.): glabra; caule tenui stricto pauciramoso; foliis parvis (3 – 4 lin. longis) lanceolatis acuminatis integerrimis uninerviis margine incrassato revolutis in petiolum brevem attenuatis, rhaphidibus copiosis supra obliquis subtus sæpius mediano parallelis; cymis simplicibus contractis monoicis vel dioicis pedunculo folia subæquante suffultis. — "Ad saxa in sylvis; Junio. Flores purpurascentes." (1451.)

PILEA LUCIDA, Bl., β. CUNEIFOLIA, Wedd. "Capitula mascula rubra vel rosea." (1448.) — Var. SERRULATA (*P. Cubensis*, Wedd.) (1448[a], 1451, ex Griseb.)

PILEA NUDICAULIS, Wedd. (528.) Var. SALICIFOLIA, Wedd. (530.)

PILEA PARIETARIA, Bl. (529.)

PILEA CORYMBOSA, Bl. (1449.)

PILEA SWARTZII, Wedd. (533.) [Eadem est 534 et var. anisophylla? 540.]

PILEA NUMMULARIFOLIA, Wedd. (1455.)

PILEA DEPRESSA, Bl.; forma foliis minutis, 2 lin. fere diametro. (1678, 1682.)

PILEA ROTUNDATA, Griseb. Fl. Ind. Occ.; var. foliis subintegerrimis. (1457, 1680.)

PILEA WYDLERI, Bl. (535.)

PILEA REPENS, Wedd. (539, 539[a], 1454.)

GYROTÆNIA, n. gen. Flores dioici; ♂ glomerato-spicati, calyce 4-partito; ♀ nudi, dense glomerati, glomerulis fasciam gyrosam in rhachi complanata carnosa demum revoluta efformantibus, involucello exiguo diphyllo. Stigma penicillatum, sessile. Achenium nudum, rectum. — "Arbor parva," foliis alternis trinerviis serratis, stipula axillari persistente. — Genus Procridearum *Pileam* cum *Myriocarpa*, cui inter Bœhmerieas accedit, connectens, inflorescentia fœminea ab omnibus distinctum.

GYROTÆNIA MYRIOCARPA, Griseb. — Rami et petioli hirsuti. Folia lanceolato-elliptica seu elliptica, acuminata vel acuta, eroso-serrata, rhaphidibus ovoideis supra scabra, pubescentia, glabrata, pilis in nervis subtus diutius persistentibus, 3 – 1 poll. longa. Spicæ utriusque sexus fere pollicem longa; rhachis fœminea demum lin. 2 lata: achenia minuta, creberrima. [Ex. cl. Wright "achenia innumera in rhachi pulposa subpellucida albida pl. m. lobata nidulantia. In sylvis prope Monte Verde, rara."] (531[a], masc., 531, fœm.)

BŒHMERIA CYLINDRICA, W., var. LITTORALIS, Sw.! (1450.)

POUZOLSIA REPENS, Griseb. (n. sp.): caule suffruticoso diffuso radicante; foliis parvis (2 – 6 lin. longis) oppositis inæqualibus ovatis acutiusculis petiolatis sparsim pilosis supra basin serratis, serraturis utrinque 2 – 6; glomerulis monoicis axillaribus vel foliis caducis interrupte spicatis; calyce ♂ 4-partito, ♀ adnato breviter bidentato, fructifero lævi ovata. — "In muris, ad Monte Verde, Dec." [Ex adn. cl. Wright calyce ♀ minutim 3-dentatus.] (1459.)

PHENAX URTICIFOLIUS, Wedd. [sed floribus pentandris]. (532.)

ROUSSELIA LAPPULACEA, Gaud. (1681.)

POLYGONEÆ.

Coccoloba tenuifolia, L. Bacca ovoidea, inferne tricarinata. (1395.) [Hujus var.? foliis supra nitidis, no. 1668[a].]

Coccoloba Leoganensis, Jacq. [Venæ primariæ subtus prominentes.] (1393.)

Coccoloba punctata, L., var. parvifolia, Griseb. (1394.) Forma foliis supra politis. (462, 462[a].)

PIPERACEÆ.

Peperomia nummularifolia, Kth. (520, 521.) [Eadem species est 518.]

Peperomia exilis, Griseb. Fl. Ind. Occ. p. 164. (519.)

Peperomia tenella, Dietr. (523.)

Peperomia glabella, Dietr. (506.)

Peperomia acuminata, Miq., non R. & P. (504.)

Peperomia dendrophila, Schlecht. (505.) Forma fructu stipitato. (503.) Forma parvifolia, foliis obtusiusculis. (1688.)

Peperomia hirtella, Miq. (512.) [Huc 511, quoad coll. 1856 – 7.]

Peperomia ionophylla, Griseb. (n. sp.): caule succulento puberulo ascendente ramoso inferne radicante; foliis (pollicaribus vel sesquipollicaribus) subcordato-deltoideis obtusiusculis puberulis demum glabrescentibus 5-nerviis epunctatis petiolum 3 – 4-plo superantibus; amentis axillaribus densifloris; ovario ovoideo-oblongo apice stigmatifero; stigmate minuto. — "Prope Monte Verde, in truncis præsertim caducis sylvarum repens." (516.)

Peperomia repens, Kth. (517.)

Peperomia hernandifolia, Dietr. (497.)

Peperomia producta, Griseb. Fl. Ind. Occ. p. 166. "In sylvis opacis, scandens." (501, 508, 1420.)

Peperomia distachya, Dietr. (499, 1419.) Forma foliis longius acuminatis. (502.)

[Peperomiæ spec. indeterminata est 498.]

Peperomia obtusifolia, Dietr. (509, 510.) Forma grandifolia. (1689.) Var. cuneata, Miq. (511, quoad coll. 1859.)

PEPEROMIA ALPINA, Dietr. (507.) [Huc forte pertinet 500.]

PEPEROMIA MYRTILLUS, Miq. (522.)

PEPEROMIA OBVERSA, Dietr. (515.)

POTHOMORPHE PELTATA, Miq. (496[a], coll. 1859 – 60.) [= Pl. Fendl. Chagres, no. 264.]

POTHOMORPHE UMBELLATA, Miq. (496.) [= Pl. Fendl. Venezuel. 1147. —No. 1146 ejusdem coll. = *P. speciosa.*]

ENCKEA AMALAGO, Griseb. Fl. Ind. Occ. p. 169. (513.) Var. β. HIRTELLA. (514.)

ARTANTHE SCABRA, Miq. (493.)

ARTANTHE GENICULATA, Miq. (1417, 1418.)

ARTANTHE ADUNCA, Miq. (494, 773, 1687.)

OTTONIA SPHÆROCARPA, Griseb. (n. sp.): dichotoma, glabrescens; foliis (3 – 2 poll. longis) ellipticis acutis basi subobliquis chartaceis pellucido-punctatis; baccis depresso-globosis sessilibus. — Recedit a typo generis ovariis baccisque foveæ rhacheos insertis sessilibus et semine globoso; convenit staminibus 4 circa ovarium insertis, stigmatibus 4 sessilibus: bracteæ minutæ, basilares, deciduæ. — "Prope Monte Verde, in sylvis densis. Frutex 2 – 5-pedalis, ramis patentissimis, spicis floriferis albis." (495.)

CHLORANTHEÆ.

HEDYOSMUM NUTANS, Sw. — "Caulis suffruticosus circiter orgyalis." (491, 1416.)

HEDYOSMUM ARBORESCENS, Sw. — Amenta mascula oblonga, obtusa, fere pollicaria, demum nutantia, structura cum præcedente conveniunt. "Frutex 4 – 6-pedalis." (490, 1415.)

TEREBINTHACEÆ.

BURSERA GUMMIFERA, L. (1155.)

ICICA COPAL, Rich. "Arbor gracilis, floribus pallide flavis." (1156, 1157.)

ICICA HEPTAPHYLLA, Aubl. (1603, florif.: "arbor gracilis, floribus luteo-albis;" 1158, fructif.: "frutex debilis, 10 – 15-pedalis, subscandens.")

AMYRIS MARITIMA, Jacq. (66.) Forma foliis basi cuneata rhombeis. (1580.)

AMYRIS SYLVATICA, Jacq., var. foliolis ovato-lanceolatis acuminatis. (1581.)

AMYRIS BALSAMIFERA, L. "Frutex odore rutaceo." (1606.)

AMYRIS LINEATA, C. Wright, mscr. (n. sp.): foliis sparsis unifoliolatis; foliolis coriaceis lineari-lanceolatis ensiformi-acuminatis integerrimis, venis parallelis approximatis utrinque prominulis rectis angulo acuto a costa ad marginem cartilagineam decurrentibus; petiolo gracili apice nodoso; corymbis paucifloris; petalis subrotundis; antheris globosis; bacca globosa. — Species in genere heteroclita, structura tamen non recedit, nisi disco intra stamina in carpophorum distinctum elevato et pericarpio molli. — "In præruptis prope Monte Verde, Feb. Arbor gracilis "40-pedalis, ligno lentissimo." (1154.)

[MANGIFERA INDICA, L. Nat. (68.)] ANACARDIUM OCCIDENTALE, L. (67.)

AMENTACEÆ.

MYRICA PUNCTATA, Griseb. (n. sp.): foliis lanceolatis integerrimis (vel paucicrenulatis) glabris subtus dense aureo-punctatis; amentis dioicis, masculis breviter cylindricis gracilibus (1–2 lin. longis); fructu minuto subgloboso (lineam diam.). — Affinis *M. microcarpæ*, Benth. — "In saxosis prope Monte Verde, Feb. Frutex 10–15-pedalis."

LEGUMINOSÆ.

CROTALARIA LOTIFOLIA, L. (118, 1589.) [CROTALARIA INCANA, L. (119.)]

[CROTALARIA RETUSA, L. (117.)] TEPHROSIA CINEREA, Pers. (120.)

ÆSCHYNOMENE BRASILIANA, DC., var. (123.)

ÆSCHYNOMENE AMERICANA, L. (124 aut 125, lomento glaberrimo; 1590, lomento hispido.)

DESMODIUM ADSCENDENS, DC. [Stipulæ in speciminibus sæpe inferne connatæ, lomentum margine dorsali fere ad suturam sinuato!] (1176.) [=127.]

DESMODIUM INCANUM, DC. [Stipulæ in specim. distinctæ; lomentum minus quam in præcedente sinuatum! Cf. char. in Fl. Ind. Occ.] (126.)

[DESMODIUM TRIFLORUM, DC. (124 v. 125.)] DESMODIUM AXILLARE, DC. (128.)

STYLOSANTHES PROCUMBENS, Sw. (1589, bis.) STYLOSANTHES VISCOSA, Sw. (122.)

BRYA EBENUS, DC. (1597.) [ABRUS PRECATORIUS, L. (121.)]

RHYNCHOSIA PHASEOLOIDES, DC. (133, forma glabrata; 134, foliolis subtus velutinis reticulatis.)

RHYNCHOSIA PARVIFOLIA, DC. (132.) [RHYNCHOSIA MINIMA, DC. (132^a.)]

CLITORIA TERNATEA, L. (1592.) CENTROSEMA PLUMIERI, Benth. (129.)

CENTROSEMA PUBESCENS, Benth. "Flores rosei, centro purpurei." (130.)

CENTROSEMA VIRGINIANUM, Benth. (131.) Var. ANGUSTIFOLIUM, DC. (1177, 1178.)

CENTROSEMA HASTATUM, Benth. "In sylvis umbrosis: flores viriduli." (1591.)

TERAMNUS UNCINATUS, Sw. (138.)

GALACTIA (SWEETIA) ANGUSTIFOLIA, Kth.: forma stylo rectiusculo et foliolis sæpe solitariis. "Ad urbem Guantanamo. Flores rubri." (1179.)

GALACTIA PARVIFOLIA, Rich. Cub. "Ad Villam Nouvelle Sophie: volubilis; flores purpurei." [Specimina perpauca, vix florifera, haud distributa.]

GALACTIA BRACHYODON, Griseb. (n. sp.): caule volubili; foliolis 3 ovati-oblongis obtusis vel emarginatis puberulis vel subtus glabratis, petiolo ipsis æquilongo seu longiori; racemis folia æquantibus vel superantibus; calycis dentibus ovatis imbricatis tubo breviter campanulato duplo brevioribus, superiori rotundato, cæteris acutiusculis, lateralibus paullo brevioribus; legumine (juniori) villoso arcuato. — "Prope Monte Verde. Corolla pallide purpurea." (135, 1180.)

GALACTIA FILIFORMIS, Benth. (136, 1593.)

VIGNA UNGUICULATA, Walp. ex Jacq. Vind. 1, t. 23. (1594.)

VIGNA LUTEOLA, Benth. (1182, 1595.)

PHASEOLUS SEMIERECTUS, L. (137.)

CANAVALIA CUBENSIS, Griseb. (n. sp.): glabra; caule volubili; foliolis coriaceis subrotundo-ovalibus mucronulatis utrinque reticulato-venosis; calycis labio superiori late bilobo tubum subæquante, inferiori minimo integro; vexillo reflexo obsolete biauriculato; carina erostri apice incurva obtusa alas superante; legumine stipitato compresso oblongo, costis juxtamarginalibus. — Corolla purpurea, $\frac{2}{3}$ poll. longa: legumen et semina *C. gladiatæ*, DC. — "In sylvis, arbores alte scandens." (139.)

DIOCLEA RUDOLPHIOIDES, Griseb. (n. sp.): foliolis parvis (pollicaribus) lanceolato-oblongis obtusis margine revolutis glabris; racemis longe pedunculatis; bracteis bracteolisque minutis; calyce pedicello brevi multo longiori, lobo superiori ovato acuto, inferiori lanceolato, utroque tubum subæquante; vexillo obovato exauriculato alas carinamque lævem æquante; antheris omnibus fertilibus; legumine 10–15-spermo rufo-villoso compresso leviter arcuato. — Vexillo ecarunculato ad *Rudolphiam* accedit. — "In pinetis prope Monte Verde; florif. Junio, fructif. Sept. Inflorescentia, calyx, etc. atrorubentes: corolla coccinea." (1181.)

MUCUNA PRURIENS, L. (140.) ERYTHRINA CORALLODENDRON, L. (1183.)

LONCHOCARPUS LATIFOLIUS, Kth. (142 [et 141], 1184.)

LONCHOCARPUS SERICEUS, Kth. (1185, 1186.)

ANDIRA MICROCARPA, Griseb. (n. sp.): foliolis 3–4-jugis late oblongis (3–4 poll. longis) utrinque rotundatis supra lucidis subtus glabratis; racemis in paniculam amplam laxam digestis, ramis inferioribus distantibus pubescentibus; calyce campanulato basi acutiusculo pubescente, dentibus late triangularibus; petalis subæqualibus (4 lin. longis); staminibus $\frac{9}{1}$; ovario breviter basi attenuato ad marginem piloso; legumine subsessili semi-ellipsoideo compressiusculo lævi (6 lin. longo). — Similis *A. retusæ*, Kth., cui flores breviores; præterea ovario stipite brevi latiusculo marginumque pube, calyce multo breviori fructuque nostra differt. — "In præruptis prope Monte Verde. Arbor elata: corolla pallide purpurea." (1187, 1188.)

BELAIRIA MUCRONATA, Griseb. (n. sp.): foliolis 9–3 lineari-oblongis mucronatis glabris. — Specimen fructiferum leguminibus subfasciculatis membranaceis venosis indehiscentibus stipitatis cum *B. spinosa*, Rich. Cub. convenit, nec nisi foliolorum forma ab ejus descriptione recedit. Genus *Leptolobiearum* foliis e gemma axillari folii abortivi in spinas longissimas stipulares reducti oriundis singulare. — "In præruptis ad Monte Verde, Oct. Frutex ultra-orgyalis." (1598.)

PŒPPIGIA PROCERA, *Presl.* "Arbor parvula." (145, 1596.)

HÆMATOXYLON CAMPEACHIANUM, L. (143.)

CASSIA FISTULA, L. [Culta; specimina haud distributa.]

CASSIA LIGUSTRINA, L. (149, 1190.)

CASSIA DECIPIENS, Desv. Specimen fructiferum: species sectionis *Chamæsennæ*, foliolis 3 poll. longis et vix lineam latis singularis, glandula petiolari tereti acuminata a basi infimoque pari æquidistante, diagnosi Desv. nimis succincta incerti nominis. — "In rupibus ad Nouvelle Sophie, Nov.: 2–3-pedalis." (1601.)

CASSIA DOMINGENSIS, Spreng. (150.)

CASSIA OBTUSIFOLIA, L.; var. foliolis oblique elongatis subretusis mucrone destitutis puberulis. (1602.)

CASSIA LINEATA, Sw., var. BRACHYLOBA. — A specimine Swartziano differt caule suffruticoso, foliolis 4–6-jugis, legumine breviori 4–6-spermo. (146.)

CASSIA SERICEA, Sw. (148.)

CASSIA SERPENS, L. (147.)

CASSIA NICTITANS, L. (1599.)

CASSIA PATELLARIA, DC. (1600.)

HYMENÆA COURBARIL, L. (1189.)

ATELEIA CUBENSIS, Griseb. — Syn. *Swartzia multijuga*, Rich. Cub. t. 42. "In rupibus prope villam Nouvelle Sophie. Arbor parvula: corolla albida vel luteola." (144.)

CALLIANDRA COLLETIOIDES, Griseb. (n. sp.): Eucalliandra, spinis stipularibus patentibus folia multo excedentibus armata, glabrata; pinnis unijugis glandula petiolari distinctis; foliolis minutis (vix lineam longis) 3 – 2-jugis obovatis glabris; capitulis globosis breviter pedunculatis; corolla strigosa calycem striatum glabrum triplo superante; staminibus 10 purpureis corollam quadruplo superantibus in tubum gracilem corollæ subæqualem connexis; legumine recto a medio ad basin attenuato oligospermo pubescente, valvis chartaceis intra margines prominulos planiusculis. — Affinis videtur *C. hystrici* (*Ingæ*, Rich.) et *C. paucifloræ* (*Acaciæ*, Rich.). "In præruptis montium prope Nouvelle Sophie, etc., Oct. Frutex 6 – 8-pedalis: stamina punicea." (153.)

CALLIANDRA GRACILIS, Griseb. (n. sp.): Eucalliandra, inermis, glabra; pinnis bijugis; foliolis (12 – 6 lin. longis) 8 – 3-jugis inæquilateris obovatis vel obovato-oblongis subacutis obtusisve basi in latere exteriori truncatis, inferioribus decrescentibus; capitulis pedunculatis; legumine recto lineari basi attenuato glabro, valvis chartaceis ad semina tumidis. — Flos ignotus. Legumen 4 – 3 poll. longum, 3 lin. latum, margine prominulo cartilagineo. [In speciminibus coll. 1860 flores pauci adsunt, pallidi, glabri; petalis estriatis infra medium connatis calycem profunde 5-fidum duplo superantibus staminibus sub-40 basi monadelphis 3 – 4-plo brevioribus. Ex cl. Wright, "frutex 6 – 10-pedalis, in præruptis."] (151.) [154 videtur eadem.]

PITHECOLOBIUM FILICIFOLIUM, Benth., var. Recedit a vulgari forma pinnis 9 – 3-jugis. (1191, 1191[a].)

[MIMOSA PUDICA, L. (152.)]

CHRYSOBALANEÆ.

CHRYSOBALANUS ICACO, L. (1607.) HIRTELLA TRIANDRA, Sw. (155.)

ROSACEÆ.

PRUNUS OCCIDENTALIS, Sw. (156.) PRUNUS SPHÆROCARPA, Sw. (1193.)

PRUNUS PLEURADENIA, Griseb. Fl. Ind. Occ. Specimina fructifera. (1192.)

MYRTACEÆ.

GOMIDEZIA LINDENIANA, Berg in Linnæa, 29, p. 208. "In monte Lomo del Gato. Arbor parvula." (162.)

CALYPTRANTHES CHYTRACULIA, Sw. (163, 172.)

Calyptranthes calyptrata, Griseb. (n. sp.): ramulis cylindricis pedunculis foliisque novellis rufo-strigosis; foliis ovato-lanceolatis in acumen obtusum longe protractis opacis petiolatis, mediano supra impresso subtus prominente, venis inconspicuis; pedunculis axillaribus simplicibus petiolo duplo longioribus [nunc folio dimidio tantum brevioribus] glomerulo florum terminatis; bracteis elongatis supra gemmas in calyptram rostriformem connatis basi circumscissis; floribus sessilibus; calyce ovoideo obtusiusculo rufo-strigoso. — Folia pollicaria vel sesquipollicaria, 6 – 3 lin. lata. Pedunculi 2 [– 6], calyptra 4, flores 1, lin. longi. (165.)

Calyptranthes decandra, Griseb. (mscr. in pl. Rugel.): ramulis cylindricis parce puberulis glabratisque; foliis obovatis (v. spathulato-lanceolatis) obtusis glabratis opacis, venis arcu connexis tenuibus vel inconspicuis; pedunculis trifidis folio superatis; floribus ternatis subsessilibus; calyce subgloboso mucronulato puberulo; petalis nullis; staminibus vulgo 10; bacca globosa limbo calycis repando coronata. — "Arbor" (Rug.): folia 1½ – 1 poll. longa, 12 (– 5) lin. lata, pube minuta adpressa, mox glaberrima. Calyx semilineam longus. [Ex cl. Wright "arbor parvula, gracilis, in sylvis prope Monte Verde, Jan." Fructifera.] (1203.)

Calyptranthes punctata, Griseb. (n. sp.): ramulis cylindricis rufo-pubescentibus demum glabratis; foliis rigidis lanceolato-oblongis obtusis opacis supra impresso-punctatis subtus adpresso-puberulis glabratisque, venis tenuibus supra inconspicuis; pedunculis axillaribus simplicibus crassiusculis ancipitibus folium subæquantibus glomerulo florum terminatis; bracteis ovato-rotundatis flore sessili multo brevioribus; calyce minute mucronulato, mucrone obtusiusculo. — Affinis videtur *C. Thomasianæ*, Berg.: folia 18 – 10 lin. longa, 6 – 2½ lin. lata: calyx 1½ lin. diam. — "Arbor parvula vel frutex, secus rivulos prope Monte Verde; Junio." (1204.)

Calyptranthes rigida, Sw. (166.)

Calyptranthes rostrata, Griseb. (n. sp.): glabra; ramulis biangulatis; foliis rigidis ovatis obtusiusculis basi rotundatis opacis, venis arcu connexis tenuibus; pedunculis tri – unifloris; pedicellis crassiusculis flore multo brevioribus; calyce ovoideo abruptim rostrato, rostro obtuso; petalis nullis; bacca globosa, limbo truncato. — Folia 1 – 2½ lin. poll. longa, 8 – 12 lin. lata. Pedunculi 4, calyces 2, lin. longi. — "In sylvis densis prope Monte Verde; florif. Junio, fructif. Jan. Frutex vel arbuscula: alabastra viridula demum badia: stamina flavida." (174, 1216.)

Calyptranthes rotundata, Griseb. (n. sp.): glabra; ramulis biangulatis; foliis rigidis elliptico-rotundatis obtusiusculis opacis, venis tenuibus vel inconspicuis; baccis

globosis solitariis sessilibus. — Flos ignotus, sed ex semine et ramulis biangulatis vix dubie præcedentibus congener. Folia 12 – 10 lin. longa, 8 – 6 lin. lata, basi rotundata. — "In præruptis prope Monte Verde, Dec. Frutex 8 – 12-pedalis; bacca rubra." (1215.)

MYRCIA CORIACEA, DC., var. RETICULATA, Griseb.: glabra; foliis pellucido-punctatis vulgo utrinque reticulato-venosis; pedunculis 3 – 15-floris. (1197, 1198, 1199, 1201.)

MYRCIA SPLENDENS, DC. (170.)

EUGENIA REVOLUTA, Berg! Syn. *E. heterophylla*, Rich.? (167, 1212.)

EUGENIA BUXIFOLIA, W. (168, 1210 [1213], 1214.)

EUGENIA LATERIFLORA, W. (1613.)

EUGENIA GLABRATA, DC. (1206, 1207.)

EUGENIA CINCTA, Griseb. (n. sp.): ramulis pilosiusculis; foliis glabris rigidis obovatis obtusis vel ovalibus (14 – 8 lin. longis) basi subacutis opacis subtus punctato-rugulosis et callo juxtamarginali crasse prominulo ab arcu venarum distante cinctis, venis distantibus parum subtus prominulis; floribus glomerulatis; pedicellis longioribus petiolum subæquantibus; bacca globosa. — "In sylvis prope Monte Verde, secus rivulos, Junio – Julio. Frutex ultra-orgyalis, floribus albis, baccis rubris." (1205.)

EUGENIA VIRGULTOSA, DC. (171.)

EUGENIA PALLENS, DC. (1211.) [Huc 91, florif.]

EUGENIA DOMINGENSIS, Berg. Proxima *E. æruginea*, DC., distincta bacca globosa. "Arbor elata, in sylvis opacis circa Monte Verde. Flores albi. Ovula in loculis 4 – 5, pendula. Bacca matura lutea." (164, 1202.)

EUGENIA PROCERA, Poir. (1612.) [Huc forte 173, fructif.]

EUGENIA LIGUSTRINA, W. (169, 1208.)

EUGENIA BERGIANA, Griseb. Syn. *Stenocalyx pseudopsidium*, Berg. — Bacca globosa, pleiosperma, seminibus trigonis. Nostra forma *E. lineatæ*, DC. similis, sed floribus pedicellatis lateralibusque distincta: bracteolis longioribus et calycis lobis acuminato-lanceolatis apice obtusiusculis parum a descriptione cl. Berg recedit. "In pinetis et præruptis prope Monte Verde. Frutex 6 – 10-pedalis; flores albi; Julio." (1194, 1200.)

[EUGENIA FLORIBUNDA, West? *Myrciaria floribunda*, Berg? In sylvis opacis prope Monte Verde, Aug. (florif.); in præruptis ad Nouvelle Sophie, Nov. (fructif.): bacca

nigra, grate acida. Arbuscula." Char. omnino *Myrciariæ*, Berg, nisi ovarii loculis circiter 5-ovulatis. Species a Grisebachio casu omissa. (1209, coll. 1859 florif., coll. 1860 fructif.)]

Eugenia § Myrciaria? aff. præcedenti; differt foliis ovatis subcoriaceis magis punctatis, bacca arcte sessili, ovario deflorato depresso, pedicello brevissimo percrasso, loculis bi-ovulatis. "Frutex 4–6-pedalis in collibus prope Nouvelle Sophie, Sept. (fructif.) Bacca rubra." Etiam a Grisebachio neglecta. (1610.)]

[Pimenta officinalis, Berg. (479.)]

Psidium calycolpoides, Griseb. (n. sp.): glabrum; ramulis compressiusculo-cylindricis; foliis chartaceis elliptico-oblongis vel obovato-oblongis basi plerumque acutis lævibus pellucido-punctatis (2–3 poll. longis); pedicellis lateralibus fasciculatis demum ancipitibus (4–8 lin. longis); calycis lobis 4 ovato-oblongis obtusis; antheris subglobosis. — Affine *P. cordato*, Sims: semen generis. — "Arbor gracilis, in sylvis umbosis, Junio–Julio." (1195, 1196.)

Mouriria spathulata, Griseb. (n. sp.): ramulis tetragonis demum cylindraceis; foliis spathulato-oblongis seu ovalibus obtusis basi in petiolum brevem attenuatis, venis tenuibus demum subtus conspicuis; fasciculis corymbisve 3–4-(–1-) floris petiolo longioribus axillaribus seu lateralibus, pedicellis infra medium minute bibracteolatis; calycis tubo campanulato, dentibus deltoideo-rotundatis; antheræ loculis calcare recurvo obtuso multo longioribus. — "La Perla, Maio. Arbuscula, floribus albis." Eandem leg. Linden (pl. Cub. 2147). (1234.)

Mouriria lanceolata, Griseb. (n. sp.): ramulis tetragonis demum cylindraceis; foliis lanceolatis acuminatis apice obtusiusculis vel mucronulatis basi in petiolum attenuatis aveniis; pedicellis geminis vel solitariis petiolo multo longioribus infra medium minute bibracteolatis axillaribus seu lateralibus; calycis tubo turbinato, dentibus mucronulato-rotundatis margine laceris; antheræ loculis calcare recurvo obtuso duplo longioribus.— "Prope Monte Verde in præruptis. Frutex 10-pedalis." (1235.)

MELASTOMACEÆ.

Calycogonium stellatum, DC. Forma foliis basi acutis subtus rufescenti-lepidotis. Calyx cum icone Bonpl. plane convenit, dum cl. Naudin diagnosis ad *C. Cubensi* magis accedit. (190.)

Calycogonium Cubense, Rich., var. — Non differt ab icone Rich. nisi flore sessili in axilla solitario; sed unicus tantum flos in specimina exstat. (1226.)

Calycogonium heterophyllum, Naud.! "Frutex ultra-orgyalis, in sylvis opacissimis prope Monte Verde. Flores purpurei: fructus atro-purpureus." (1220.)

Calycogonium Wrightianum, Griseb. (n. sp.): glabrum; foliis ellipticis seu elliptico-oblongis obtusiusculis triplinerviis, nervorum axillis subtus glanduliferis; pedicellis axillaribus solitariis calyce longioribus; calyce inferne subtetragono, lobis superne filiformi-triquetris tubum subæquantibus; stylo filiformi; stigmate minuto. — Affine *C. Lindeniano*, Naud. et *C. glabrato*, DC. — "Prope Monte Verde secus rivulos; fl. Julio; fr. Dec. Frutex 6 – 16-pedalis: petala rosea: baccæ cæruleo-atræ." — Idem leg. Linden (pl. Cub. 2134). (192, 193.)

Calycogonium involucratum, Griseb. (n. sp.): ramulis puberulis; foliis elliptico-oblongis seu ovali-rotundatis obtusis triplinerviis, nervorum axillis subtus barbatis, venis transversis subtus prominulis; glomerulis subtrifloris pedunculatis; bracteis ovalibus pluribus glomerulum cingentibus; calycis tubo hispido subgloboso lobis foliiformibus longiori. — "Prope Monte Verde. Frutex elata: petala rubra." (194, 1225.)

Calycogonium echinatum, Griseb. (n. sp.): ramulis nervoque foliorum subtus rufo-puberulis; foliis lanceolatis apice obtusis vel emarginatis *uninerviis*, venis tenuissimis subremotis; pedicellis axillaribus solitariis petiolo brevioribus; calycis tubo globoso setis mollibus echinato lobis dentiformibus lanceolato-linearibus obtusiusculis multo longiori. — Flos ignotus, sed ovarii vel baccæ junioris structura cum ceteris congrua. — "Prope Monte Verde, in sylvis; Dec. Frutex 6 – 10-pedalis." (1221.)

Ossæa punctata, Griseb. (n. sp.): ramulis nervisque foliorum subtus rufo-furfuraceis; foliis elliptico-oblongis mucronato-acutiusculis basi acutis integerrimis triplinerviis glabris subtus rufo-punctatis; fasciculis paucifloris; flore —; bacca quadri-loculari. — Proxima et simillima *O. fasciculari*, Griseb., quæ pube hispida differt. — "Prope Monte Verde, in sylvis densis; Dec. Arbor 20 – 30-pedalis." (1223.)

Clidemia Lima, DC. (189, 1233.)

Clidemia capillaris, Griseb. Syn. *Sagræa capillaris*, DC. (1229.)

Clidemia scabrosa, Griseb. Syn. *Ossæa scabrosa*, DC. "Petala rosea, filamenta cerina, antheræ fere albæ." (1232.)

Clidemia lanata, Griseb. (non DC.) Syn. *Sagræa lanata*, Naud. *C. scabrosa*, var. Griseb. olim. Paullo recedit specimen cl. Naudin originarium (coll. Linden) foliis supra brevius strigillosis subtus densius villosis et nervis lateralibus magis basi approximatis: pube villosa imprimis a *C. scabrosa* differt. — "Prope Monte Verde. Frutex circa 4-pedalis, fructu læte cyaneo." (177.)

CLIDEMIA RUBRINERVIS, Griseb. Syn. *Sagræa rubrinervis*, Naud. Glomerulo unilaterali bracteis incluso longe pedunculato connectit *Staphidiastra* cum *Staphidio* habitumque præcedentium sequitur. — "Petala rosea: baccæ atropurpureæ." (1230, 1231.)

CLIDEMIA HIRSUTA, Griseb. Syn. *Sagræa hirsuta*, DC. "Frutex sat elatus, in sylvis densis. Petala rosea." (1228.)

CLIDEMIA WRIGHTII, Griseb. (n. sp.): ramulis et petiolis pube rufa adpressa furfuraceo-puberulis; foliis ovatis acutis præter nervum juxta-marginalem eximie triplinerviis denticulatis supra glabris subtus ad nervos venasque transversas furfuraceo-puberulis; petiolo cymam trifidam furfuraceam subæquante; calycis tubo globoso, dentibus 4 rotundato-mucronatis abbreviatis; petalis —; bacca 4-globosa. — Proxima *C. Swartzii*, Griseb., quæ pube differt: nervi laterales a basi folii 6 lin. fere distant. — "Prope Monte Verde in sylvis densis, Julio. Frutex orgyalis, fructu cæruleo-purpureo." (1219.)

CLIDEMIA PENNINERVIS, Griseb. (n. sp.): ramulis obsolete tetragonis foliosis petiolisque sparsim pilosis; foliis lanceolato-linearibus acuminatis *uninerviis* supra glabris subtus glabrescentibus vel in nervo pilosis, venis transversis; pedunculis capillaribus uni-paucifloris folio 3-4-plo superatis; bracteolis breviter linearibus; calyce tubuloso dentibus 4 subulatis longiori; petalis —; bacca globosa; stylo filiformi. — Affinis *C. capillari* et haud dubie ejusdem sectionis. — "Secus rivulos prope Monte Verde. Frutex gracilis, ultra-orgyalis: baccæ læte cæruleæ." (175.)

CLIDEMIA HIRTA, Don. (176.) [Var.? foliis longe tenuiter acuminatis est 178.]

HETEROTRICHUM NIVEUM, Don. (188.) DIPLOCHITA SERRULATA, DC. (180.)

TETRAZYGIA SEMICRENATA, Griseb. Syn. *Conostegia semicrenata*, Sw. (182.)

TETRAZYGIA ELÆAGNOIDES, DC. (1222.)

MICONIA IMPETIOLARIS, Don. "Baccæ atropurpureæ." (1224.)

MICONIA LÆVIGATA, DC. (184, 185.)

MICONIA EURYCHÆNIOIDES, Griseb. (n. sp.): ramulis obtuse tetragonis petiolisque rufo-lepidotis; foliis ellipticis cuspidatis basi obtusiusculis integerrimis trinerviis supra nitide glabris subtus aurato-lepidotis, nervis lateralibus margini quam mediano magis approximatis venisque transversis subtus prominulis; panicula trichotoma rufo-lepidota; floribus breviter serialibus; calycis tubo ovato læviusculo, dentibus obsoletis; antheris 10 clavato-linearibus basi bituberculatis, poro terminali rotundo duplici; stigmate capitulato; bacca triloculari oligosperma. — Syn. *Eurychænia punctata*, var. *latifolia*,

Griseb. olim. Simillima *Eurychæniæ punctatæ*, quæ foliis angustis ramisque cylindricis differt: antheræ porro structura, quæ est *Miconiæ*, in quo genere sectionem propriam (*Pseudoeurychæniam*) sistit, antheris versus apicem paullisper dilatatis et fructu *Eurychæniæ* distinguendam. Semina convexo-trigona, gemina in loculis matura exstant. Eadem species in Venezuela (Fendl. no. 1841) occurrit. "In monte La Guinea dicto, Dec. – Jan. Arbor gracilis, 20 – 30 ped. alta: petala alba versus apicem purpureo tincta." (183, 1614.)

Cremanium tetrandrum, Griseb. Syn. *Tetrazygia tetrandra*, DC. "Arbor 40 – 60-pedalis." (186, 1227.)

Cremanium amygdalinum, Griseb. Fl. Ind. Occ. p. 261. (1218.) [Spec. nostra a no. 181 plane diversa videtur. "Flores" (calyces deflorati) ex cl. Wright "læte rubri," longe pedicellati, corymbi e ramis annotinis orti.] — Forma angustifolia. "Petala alba." (181.)

Catachænia alternifolia, Griseb. Pl. Amer. Trop. p. 55. Specimina serius accepta folia opposita præbent, tamen nomen jam editum mutare nolui. — "In pinetis prope Monte Verde. Frutex 10-pedalis. Petala rubentes." (179.)

Charianthus obliquus, Griseb. (n. sp.): ramulis obsolete tetragonis glabris vel furfuraceis; foliis e basi obliqua ovatis rotundatis integerrimis glabris epunctatis triplinerviis; pedicellis solitariis folio parum superatis; calycis limbo brevi obtuse 4-lobo; flore — ; capsula 4-loculari globosa carpophoro brevi suffulta. — Fructus congenerum, sed, donec flos innotescat, locus speciei in systemate dubius; folia $1\frac{1}{2} - 1$ poll. longa, chartacea, pauca in ramulis abbreviatis cito in truncum lignosum abeuntibus. — "In pinetis prope Monte Verde, Aug. Frutex humilis." (1217.)

Graffenrieda brachycentra, Griseb. (n. sp.): glabra; foliis ovato-subrotundis basi obliqua subcordatis quintuplinerviis apiculatis; cymis corymbiformibus pedunculatis; calycis lobis 4 e basi subulata patula filiformibus obtusiusculis; antheræ calcaribus rudimentariis. — Habitus *Davyæ ascendentis*, Griseb., sed magis accedit ad *Cycnopodium*. (191.)

Arthrostemma lanceolatum, Griseb. — Syn. *Chætogastra*, DC. (187.)

LYTHRARIEÆ.

Ginoria Americana, Jacq. (160.)

[Cuphea decandra, Ait. (334.)]

[Ammannia latifolia, L. (161bis.)]

Cuphea Parsonsia, R. Br. (161, 1236.)

ONAGRARIEÆ.

Isnardia palustris, L. (157.) [Jussiæa repens, L. (158.)]

Jussiæa suffruticosa, L. var. ligustrifolia, H.B.K. Syn. *J. octonervia*, Lam., non DC. (159.)

[Combretaceæ adhuc indeterminatæ, 1237, 1238, 1239, 1240, 1609.]

THYMELEÆ.

LINODENDRON, n. gen. Flores polygami, fertiles et steriles mixti. Calyx hypocraterimorphus, tubo basi tumidulo vel demum latere rumpente intus sericeo-piloso, limbo 5-partito imbricato. Squamulæ hypogynæ 5, pilis longissimis sericeis barbatæ. ♂ Stamina 10, exsertæ, fauci inserta, 5 breviora, antheris oblongis seu ovalibus, filamentis longiusculis. Ovarium sterile sericeo-barbatum, stylo longissimo. ♀ Antheræ in fauce subsessiles, abortivæ. Ovarium maris, ovulo ex apice loculi pendulo, stylo infraterminali pubescente longissimo exserto, stigmate obtusiusculo cylindraceo-conico. Fructus —. Arbores Cubenses, libro *Lagettæ* reticulato pulcherrimo, foliis sparsis, capitulis pedunculatis in corymbos terminales dispositis exinvolucratis receptaculo discoideo suffultis albo-tomentosis.

Daphnopsis Cubensis, Meisn., secundum descriptionem auctoris optimam altera generis species est, foliis angustioribus et calycis tubo lobos duplo superante distinguenda.

Linodendron Lagetta, Griseb. (n. sp.): foliis lanceolato-oblongis vel elliptico-oblongis brevissime petiolatis glabris (8 – 6 lin. latis); calycis lobis oblongis acutiusculis intus puberulis tubo (10 lin. longo) quadruplo brevioribus; antheris oblongis filamentis staminum longiorum æquilongis. — "In sylvis prope Monte Verde; Dec., Jan. Arbor elata: flores purpurascentes, odori." (1397, 1397[a].)

LAURINEÆ.

Phœbe montana, Griseb. Syn. *Laurus montana*, Sw. (476, 1406, 1407, 1411.)

Phœbe triplinervis, Griseb. (n. sp.): glabra; foliis oblongis seu elliptico-oblongis apiculatis triplinerviis, nervis subtus prominentibus axilla barbatis; racemis subsimplicibus petiolum parum excedentibus; pedicellis patentibus flore longioribus; staminibus sterilibus deltoideis fertilium serie interiori paullo superatis; bacca —. Folia 4 – 5-pollicaria, venis subtus minus quam nervi conspicuis. Calyx lineam longus, glaber, in-

fundibuliformis, 6 fidus, lobis patentibus: antheræ exteriores oblongæ, in filamentum attenuatæ. — " Prope Monte Verde, Maio. Arbor parvula, floribus viridulis." (1400.) [No. 482 est pl. fœminea, bacca immatura olivæformi calyce majusculo stipata.]

HUFELANDIA PENDULA, Nees. (485, 486, 1402, 1403, 1414.)

ACRODICLIDIUM JAMAICENSE, Nees. ([481,] 1401, 1410.)

NECTANDRA SANGUINEA, Rottb. (484.)

NECTANDRA LEUCANTHA, Nees. (480, 1399.)

NECTANDRA CUNEATA, Griseb. (n. sp.): ramulis paniculisque rufo-tomentosis; foliis coriaceis (5 – 3 poll. longis) cuneato-obovatis spathulatisque obtusis supra glabris opaco-lævibus subtus pube brevissima tandem evanida rufo-tomentosis, venis primariis novenis – duodenis subtus parum secundariis non prominulis; calycis segmentis ovatis obtusatis (sesquilineam longis); antheris oblongis in filamentum æquilongum attenuatis, 3 interioribus juxta basin biglandulosis; staminibus sterilibus lanceolato-linearibus rufo-pilosis eglandulosis; cupula cupuliformi bacca oblonga demum duplo breviori. — In no. 1413[a] bacca monstrosa disco fere ad apicem obvallatur, sicut a Neesio in *N. sarcocalyce* exponitur. — " In sylvis densis; prope Monte Verde (florif.), floribus flavo-viridulis, Aug. Prope La Perla Maio (fructif.). Arbor grandis." (1412, 1413.)

STRYCHNODAPHNE FLORIBUNDA, Griseb. — Syn. *Nectandra floribunda*, Nees. Specimina mascula prius ignota exstant, quæ staminum structuram eandem, quæ in Fl. Ind. Occ. de fœm. describitur, exhibent, nisi quod antheræ ovoideo-globosæ, 4-valvares, loculis 4 penitus exsculptæ filamento duplo breviores sunt. Baccæ vero in speciminibus prius descriptis nondum maturæ erant: maturæ (1409) ovoideo-globosæ sunt ac tum lobi cupulæ incremento tubi obsoletæ fiunt, ita ut genus, nisi dioicum esset, *Nectandræ* magis accedat. (1404, 1405, 1408, 1409.)

OREODAPHNE LEUCOXYLON, Griseb. — Syn. *Laurus*, Sw. *Ocotea puberula*, Nees. (477, [etiam forte 483, 487,] 1398.)

[CINNAMOMUM ZEYLANICUM, Breyn. Cult. (478.)]

[CASSYTA AMERICANA, Nees. (488.)]

HERNANDIA CUBENSIS, Griseb. (n. sp.): ramulis paniculisque puberulis; foliis ovatis obtusiusculis basi rotundata brevissime aut non peltatis petiolo subæquilongis glabratis; sepalis ♂ ovali-oblongis stamina superantibus; antheris ovalibus filamento æquilongis; drupa lævi. — Proxima *H. Guianensi* Aubl., quæ suadente ic. Aubl. staminibus longe exsertis, filamentis antheræ multo longioribus et drupa 8-sulcata differt. Vesica

drupam includens in nostra ovalis, pollices 2 fere longa. Antheræ loculis margine soluto aperiundis Laurinearum structuræ satis accedunt, ut genus eidem familiæ adnumerari possit. — "In sylvis prope Monte Verde. Arbor gracilis, 30–50-pedalis, ligno albo tenero, floribus albis." (1390.)

GARRYACEÆ.

Fadyenia Hookeri, Endl. — Syn. *Garrya Fadyenii*, Hook. Ic. Pl. t. 333. (492.)

CUCURBITACEÆ.

Cionandra racemosa, Griseb. Fl. Ind. Occ. p. 286. — Syn. *Bryonia racemosa*, Sw. (1243.)

Cionandra graciliflora, Griseb. l. c. — Flos masculus 7–8 lin. longus; calycis limbus cyathiformis, dentibus cyathulo æquilongis linearibus, ipse strictura abbreviata ab ovario æquilongo separatus. (1241.)

[Melothria pervaga, Griseb. (195.)] Momordica Charantia, L. (1244.)

Anguria polyphyllos, Schlecht. (196.) Feuillea cordifolia, L. (1242.)

PASSIFLOREÆ.

Passiflora minima, L. (197, 1245, pro parte.)

Passiflora angustifolia, Sw. (197, 1245, pro parte.)

[Passiflora maliformis, L., var. foliis eximie aristato-cuspidatis. (199.)]

Passiflora rubra, L. (201, 133bis.) Passiflora sexflora, Juss. (200.)

Passiflora penduliflora, Bert. (198.) Passiflora oblongata, Sw. (198[a], 1615.)

TURNERACEÆ.

Triacis microphylla, Griseb. — Syn. *Turnera microphylla*, Desv. [Est *Bohadschia humifusa*, Presl. Rel. 2, p. 98, t. 68, a Grisebachio prætermissa.] (210.)

Turnera ulmifolia, L. (209.)

HOMALINEÆ.

Homalium racemosum, Jacq. (1106.)

LOASEÆ.

Mentzelia aspera, L. (208.)

ARISTOLOCHIEÆ.

Aristolochia (Gymnolobus) trichostoma, Griseb. (n. sp.): scandens, cirrhifera, glabra; foliis cordatis pedatinerviis rotundato-obtusis subtus inter nervos glaucescentibus exstipulatis, sinu basilari late aperto; calycis tubo supra basin inflatum cylindrico (unciam longo lineam diametro) versus medium rectangulo-inflexo abruptim unilabiato, labio ovali-rotundato apice emarginato tubo quadruplo breviori utrinque a basi ad apicem longe fimbriato, fimbriis sparsis flexuosis (2–3 lin. longis). — Ex sectionibus Klotzschianis *Brachychilo* accedit. — "In sylvis prope Monte Verde." (463.)

CACTEÆ.

Cereus eriophorus, Link. (207.) [Peirescia portulacifolia, Haw. (205.)]

Rhipsalis Cassyta, Gærtn. (206.)

SAXIFRAGEÆ.

Weinmannia pinnata, L. "In pinetis prope Monte Verde, et in monte La Guinea dicto. Arbor 30–40-pedalis." (1250.)

BEGONIACEÆ.

Begonia Cubincola, A. DC. n. sp. (203, 204, 1249.)

Begonia Wrightiana, A. DC. n. sp. (202, 1246.)

Begonia, n. sp., monographo A. DC., relinquenda, affinis *B. Wrightianæ*. "In præruptis umbrosis inter Tiguabos et Montem Taurum, Junio. Flores fere albi." (1247.)

Begonia, n. sp. . . . . . affinis *B. Lindenianæ*, A. DC. "In rupibus cum præcedente. Flores pallide rosei." (1248.)

ARALIACEÆ.

Sciadophyllum Jacquini, Griseb. — Syn. *Hedera arborea*, Sw. (212.)

Panax speciosum, W. (211.)

UMBELLIFERÆ.

Hydrocotyle spicata, Lam. (213.) [Hydrocotyle umbellata, L. (214.)]

[Eryngium fœtidum, L. (215.)]

BALANOPHOREÆ.

Phyllocoryne Jamaicensis, Hook, f. "In sylvis opacissimis prope Monte Verde. Planta cæspitosa, rubens." (546.)

OLACINEÆ.

Mappia racemosa, Jacq. var. Forma a Jamaicensi recedens racemis simplicibus petiolo vix longioribus et drupa paullo breviori subglobosa (semipollicem longa). (1389, 1578.)

LORANTHACEÆ.

Loranthus pauciflorus, Sw. (1255, 1303.)

Phoradendron hexastichon, Griseb. — Syn. *Viscum hexastichon*, DC. (1252.)

Phoradendron Martinicense, Griseb. — Syn. *Viscum Martinicense*, DC. (1251, foliis 3 – 5-nervatis.)

Phoradendron latifolium, Griseb. — Syn. *Viscum latifolium*, Sw. (216, 217, 1251[a], foliis enerviis.)

Phoradendron tetrastachyum, Griseb. (n. sp.): ramulis compressis demum cylindricis; foliis obovatis apice rotundatis in petiolum attenuatis obsolete pauciveniis, venis a mediano infra medium secedentibus; spicis in axilla solitariis folio 2 – 4-plo brevioribus, articulus quadrifloris; floribus tetrastichis; baccis e basi ovata oblongatis. — Syn. *Viscum tetrastachyum*, C. Wright, mscr. — "Prope Monte Verde in *Guettardæ* sp. parasiticum." (218, 1300.)

Phoradendron rubrum, Griseb. — Syn. *Viscum rubrum*, L. (1302.)

Phoradendron macrostachyum, Griseb. — Syn. *Viscum macrostachyum*, Jacq. Spec. cum no. 220 ? mixta.

Phoradendron myrtilloides, Griseb. — Syn. *Viscum myrtilloides*, Sw. In *Faramea odoratissima* parasiticum. (1253.)

Phoradendron buxifolium, Griseb. — Syn. *Viscum buxifolium*, Lam. A præcedente differt ramulis teretibus et spicis folia avenia subæquantibus. (220, 220[a], 222, 219, 223.)

Phoradendron sessilifolium, Griseb. (n. sp.): ramulis ramisque tetraquetris; foliis obovato-oblongis obtusis basi lata sessilibus aveniis (8 – 10 lin. longis); spicis solitariis folium subæquantibus, articulis 3 – 4 subremotis; floribus tetrastichis; bacca ovato-oblonga. — "In arboribus prope La Perla." (1301.)

PHORADENDRON CONSTRICTUM, Griseb. (n. sp.): ramulis ramisque subcylindricis; foliis minutis crassis ovalibus spathulatisque in petiolum brevem contractis enerviis (3–4-lin. longis); spicis folium subæquantibus, articulis 2–3 bifloris; floribus distichis; bacca oblonga. —Syn. *Viscum constrictum*, C. Wright, mscr. — "Prope Monte Verde; in quodam fruticem Rubiaceum. Spicæ inter flores eximie constrictæ. Flores aurantiacei." (220b.)

PHORADENDRON SERPYLLIFOLIUM, Griseb. (n. sp.): nanum; ramulis striato-cylindricis; foliis minutis ovalibus enerviis petiolatis (1–2 lin. longis), inferioribus abortivis; spicis folium subæquantibus, articulis 2–3 contiguis plurifloris; floribus tetrastichis. — "In Euphorbiacea? quadam, prope Monte Verde. Flores virides." (1254.)

[Var.? aphyllum. Parasiticum in *Euonymo cuneifolio* et *Myginda latifolia*. (224.)]

ARCEUTHOBIUM EPIVISCUM, Griseb. (n. sp.): ramulis compresso-tetrapteris ad nodos constrictis, internodiis oblongo-linearibus rotundato-truncatis; squamis obsoletis deciduis; spicis ♀ moniliformibus 2–3-articulatis, articulis ovoideis plurifloris; floribus distichis. — Syn. *Viscum Epiviscum*, C. Wright, mscr. Parasiticum in *Phoradendro buxifolio*. (221.)

VISCUM DOMINGENSE, Spreng. (225.)

EREMOLEPIS WRIGHTII, Griseb. (n. sp.): ramulis angulatis lævibus; foliis alternis obovato-oblongis ovalibusque 3–5-plinerviis subsessilibus; floribus ♀ glomeratis; calycis limbo 4-partito. — Parasiticum in *Hufelandia pendula*, etc. (226.)

*** Specimina incompleta, non determinata.

No. 59 (coll. 1856–7): *Connaracea.*

1130.

1159, 1160. [*Connaraceæ.*]

VII.

Filices Wrightianæ et Fendlerianæ, — *nempe in Insula Cuba a* Carolo Wright *et in Venezuela ab* Aug. Fendler, *ann.* 1854–60, (*nonnullis Panamensibus etc. interjectis,*) *Enumeratæ cura*

DANIEL C. EATON, A. M.

(*Read August* 14, 1860.)

I. POLYPODIACEÆ.

Trib. I. ACROSTICHACEÆ.

Genus I. ACROSTICHUM, *L.*

§ I. Rhipidopteris.

1. A. peltatum, *Swartz. Syn. Fil.* p. 11. Rhipidopteris peltata, *Fée, Hist. Acrostich. p.* 78. (Fendl. No. 361. Wright, 927.)

2. A. sphenophyllum, *Kunze, Anal. Pterid. p.* 11, *t.* 6. (Fendl. 263.)

§ II. Elaphoglossum.

3. A. Herminieri, *Bory & Fée, Hist. Acrost. p.* 43, *t.* 11. (Wright, 971. Dr. S. Hayes, in Isthmo Panamensi, 23.)

4. A. latifolium, *Swartz ; Hook. Fil. Exot. t.* 42. (Wright, 790, 791, 970.)

Species quinque sequentes mihi dubiæ sunt, quarum plures, cel. Hookero (l. c.) suadente, nescio an A. latifolio conjungendæ.

5. A. pachyphyllum, *Kunze in Lin.* 9, *p.* 26. Hymenodium Kunzeanum, *Fée, l. c. p.* 90, *t.* 58. (Fendl. 293, 296.)

6. A. Lingua, *Raddi, Nov. Gen. Bras. p.* 5, *t.* 15. (Fendl. 285.)

7. A. ATTENUATUM, *Kunze* ex *Metten. in litt.* (Fendl. 290.)

8. A. SPORADOLEPIS, *Kunze* ex *Metten. in litt.* (Fendl. 287 ?, 294.)

9. A. ALISMÆFOLIUM, *Fée, l. c. p.* 28, *t.* 3. (Wright, 966, 969.)

10. A. LLOENSE, *Hook. Ic. Pl. t.* 657. (Fendl. 286.)

11. A. WRIGHTII, *Metten.* (sp. nov.): caudice elongato scandente paleis integris ovatis onusto; frondibus sterilibus remotis spathulatis vel obovato-lanceolatis in stipitem paleaceum brevem angustatis acuminatis margine undulatis utrinque paleis minutis laxissime conspersis subtus ad rachin paleis majusculis ovatis subintegris obvelatis, fertilibus minoribus ceterum consimilibus. Acr. Lloensi proxima, sed frondibus spathulatis, caudice crassiore, stipite breviore distincta. Frondes 7–12-pollicares, sesquipollicem latæ, stipiti 1–2-pollicari insidentes. Caudex ad truncos scandens, crassitie pennæ corvinæ. (Wright, 965.)

12. A. XANTHONEURON, *Kunze* ex *Metten. in litt.* (Fendl. 280.)

13. A. TOVARENSE, *Moritz* ex *Metten. in litt.* (Fendl. 292.)

14. A. STENOPTERIS, *Klotzsch in Lin.* 20, *p.* 420. (Fendl. 282.)

15. A. KLOTZSCHII, *Moritz.* Acr. Aubertii, *Desv.* simillima; an eadem? (Fendl. 265, 281.)

16. A. MARTINICENSE, *Desv.*; *Fée, l. c. p.* 45, *t.* 16. (Wright, 789, exempl. anno 1856 lecta.)

17. A. LEPTOPHYLLUM, *Fée, l. c. p.* 45, *t.* 17. (Fendl. 277.)

18. A. ERINACEUM, *Fée, l. c. p.* 41. (Fendl. 264.)

18. A. MORITZIANUM, *Klotzsch in Lin.* 20, *p.* 423. (Fendl. 362? 266. Wright, 1040.)

19. A. PROCURRENS, *Metten.* (sp. nov.): pusillum; caudice filiformi longe repente paleis lanceolatis acuminatissimis dense vestito; frondibus sterilibus obovatis obtusis basi cuneatis in stipitem brevem alatam attenuatis paleis angustis undique ciliatis, fertilibus minoribus stipite longiore.—Frondes opaco-virides, 1–6-pollicares, obovatæ, basi longe cuneatæ. Stipes et frondes præcipue ad margines paleacei; paleis fulvis e basi ovata in cilias denticulatas longissimas productis.—Ab. Acr. Moritziano, cui proxima, caudice elongato frondibusque minoribus satis distat. (Wright, 793.)

20. A. PILOSELLOIDES, *Presl. Rel. Hænk. p.* 14, *t.* 2; *Hook. Fil. Exot. t.* 29. (Fendl. 267, 268. Wright, 794. Hayes, 30.)

21. A. STRICTUM, *Raddi, Nov. Gen. p.* 49; *Martius, Ic. Crypt. Bras. p.* 84, *t.* 22. (Wright, 789, pro parte, anno 1859 lecta.)

22. A. MERIDENSE, *Klotzsch in Lin.* 20, *p.* 427. (Fendl. 269.)

23. A. PERELEGANS, *Fée, l. c. p.* 55, *t.* 23. (Fendl. 466.)

24. A. RUBIGINOSUM, *Fée, l. c. p.* 47, *t.* 5, 13. (Fendl. 273, 274. Art. Schott in Isthmo Darien. n. 82.)

25. A. VISCOSUM, *Swartz ; Hook. & Grev. Ic. Fil. t.* 61. (Fendl. 272, 275. Wright, 789, pro parte, anno 1859.)

26. A. APODUM, *Kaulf. Enum. p.* 59 ; *Hook. & Grev. Ic. Fil. t.* 99. (Fendl. 430. Wright, 967.)

27. A. BELLERMANNIANUM, *Klotzsch in Lin.* 20, *p.* 426. (Fendl. 270.)

28. A. CUSPIDATUM, *Willd.* ; *Fée, l. c. p.* 57, *t.* 14. (Fendl. 271.)

(ACROSTICHI species incertæ sunt Fendl. 276, 278, 279, 295, 391, 463, Wright, 968.)

§ III. ACONIOPTERIS.

29. A. LONGIFOLIUM, *Swartz ?* Aconiopteris longifolia, *Fée, l. c. p.* 80, *t.* 41. (Fendl. 283, 284.)

§ IV. ANETIUM.

30. A. CITRIFOLIUM, *L. Amœn. Acad.* 1, *p.* 269. Antrophyum citrifolium, *Fée, Hist. Antroph. p.* 51. (Fendl. 425.)

Genus II. OLFERSIA, *Raddi.*

1. O. CERVINA, *Kunze ; Hook. Fil. Exot. t.* 43. (Fendl. 426. Wright, 784, 785.)

Genus III. LOMARIOPSIS, *Fée.*

1. L. SORBIFOLIA, *Fée, Hist. Acrost. p.* 69. (Wright, 973.)

2. L. WRIGHTII, *Metten.* (sp. nov.): caudice elongato squamis rubiginosis lanceolatis lacero-ciliatis paleaceo ; stipitibus basi paleaceis superne glabriusculis ; frondibus remotis glabris supra obscure viridibus subtus pallidioribus, sterilium pinnis 11 – 13 subsessilibus obovato-cuneatis (terminali æquali, basali vix minore) abrupte caudatis vel acuminatis integris vel denticulatis vel eroso-dentatis, fertilium pinnis 11 – 13 remotis brevipetiolatis linearibus involutis margine membranaceo angusto cinctis. — Caudex diametro 4-linealis, modice paleaceus, ad truncos alte scandens "modo Hederæ," stipites validos semipedales sub angulo 20° emittens. Frondes pedales fere ad sesquipedales. Pinnæ remotæ, 3 – 4 pollices longæ, steriles pollicem latæ caudem semipollicarem gerentes, fertiles bilineam latæ, pagina superiora margine involuto celata. — A Lom. sorbifolia pinnis obovatis caudatis plusquam dimidio paucioribus facile dignoscenda. (Wright, 787.)

3. L. FENDLERI (sp. nov.): caudice crasso elongato valde paleaceo, paleis fulvis imbricatis lanceolatis ciliatis ; frondibus sterilibus remotis stipite valido paleaceo effultis

pinnatis, pinnis 37 – 49 subpetiolatis basi truncatis lanceolatis acuminatis membranaceo-chartaceis glabris margine undulato-dentatis vel subintegerrimis; fertilibus pinnatis, pinnis brevi-petiolatis margine tenui lato explanato cinctis. — Caudex digiti crassus, ad truncos alte scandens, paleis pallide fulvis linearibus 4 – 5 dense vestitus. Stipes cum caudice continuus, crassitie pennæ scriptoriæ, 2 – 6-pollicaris, paleaceus, e stipite sub angulo 60° divergens. Rachis tetragona, inferne paleacea, superne anguste alata. Frondes steriles bipedales, ambitu oblongo-lanceolatæ, pinnatæ; pinnæ crebræ, patentes, 4 – 5-pollicares, basali dimidio minore, terminali subæquali, brevissime petiolatæ, basi truncatæ vel subcordatæ, ad rachin articulatæ, demum articulatim secedentes, supra obscure subtus pallide virides; venulæ simplices vel furcatæ. Frondium fertilium pinnæ anguste lineares, basi cordatæ, 3 – 4 pollices longæ, 2 – 3 lineas latæ, intervalli sub-pollicari distantes; venulæ e costa valida simplices vel furcatæ, liberæ. Species pulcherrima nulla alia confundenda. (Fendl. 335.)

4. L. PHLEBODES, *Fée, l. c. p.* 66. Acrostichum Japurense, *Martius, Ic. Crypt. p.* 86, *t.* 24. (In Isthmo Panamensi. Hayes, 4. Schott, 86. Frondes visæ omnes steriles, sed haud dubiæ hic referendæ.)

Genus IV. CHRYSODIUM, *Fée.*

§ I. EUCHRYSODIUM.

1. CH. CRINITUM, *Metten. Fil. Lips. p.* 21. Acrostichum crinitum, *L.; Hook. Fil. Exot. t.* 6. (Fendl. 363. Wright, 792.)

2. CH. AUREUM, *Metten. l. c.* Acrostichum aureum, *L.* In maritimis calidioribus ubique.

§ II. ANAPANSIA.

3. CH. ALIENUM, *Metten. l. c.* Gymnopteris aliena, *Presl.; Fée, l. c. p.* 84. Acrostichum, *Swartz.* (Fendl. 336. Wright, 783.)

4. CH. NICOTIANÆFOLIUM, *Metten. l. c. p.* 22. Gymnopteris nicotianæfolia, *Presl.; Fée, l. c. p.* 86. (Wright, 788.)

5. CH. ACUMINATUM, *Metten. l. c.* Gymnopteris acuminata, *Fée, l. c. p.* 85. Lingua cervina scandens, citrei foliis major, *Plumier, Fil. Am. p.* 100, *t.* 115. (Fendl. 408, sterilis.)

Genus V. POLYBOTRYA, *H.B.K.*

1. P. CANALICULATA, *Klotzsch in Lin.* 20, *p.* 429. (Fendl. 262.)

2. P. OSMUNDACEA, *H.B.K.* (Wright, 786.)

3. P. SERRATIFOLIA, *Klotzsch in Lin.* 20, *p.* 436. Soromanes serratifolium, *Fée, l. c. p.* 82. (Fendl. 261.)

4. P. CAUDATA, *Kunze in Lin.* 9, *p.* 23; *Fée, l. c. p.* 72, *t.* 34. (Hayes, 8. Frondes steriles.)

TRIB. II. POLYPODIEÆ.

Genus VI. VITTARIA, *Smith.*

1. V. STIPITATA, *Kunze, Analecta, p.* 28, *t.* 18. (Fendl. 259, 259[b]. Wright, 865, pro parte. Schott, 61.)

2. V. FILIFOLIA, *Fée, Hist. Vittar.* p. 20, *t.* 3. (Fendl. 258. Wright, 865, pro parte.)

3. V. LINEATA, *Swartz.* (Wright, 865, pro parte.)

4. V. GARDNERIANA, *Fée, Hist. Vittar. p.* 15, *t.* 3; *Metten. in litt.* (Fendl. 260.)

Genus VII. TÆNITIS, *Swartz.*

1. T. FURCATA, *Willd. Sp. Pl.* 5, *p.* 136. (Fendl. 423. Wright, 980. Schott, 58.)

2. T. ANGUSTIFOLIA, *Spreng. Syst.* 4, *p.* 42. Pteropsis angustifolia, *Desv.; Fée, Hist. Vittar. p.* 24. (Fendl. 424. Wright, 978. Schott, 57.)

3. T. LANCEOLATA, *Kaulf. Enum. p.* 130. Pteropsis lanceolata, *Desv.; Hook. Fil. Exot. t.* 45. (Wright, 979.)

Genus VIII. ANTROPHYUM, *Kaulf.*

1. A. LANCEOLATUM, *Kaulf. Enum. p.* 198. (Wright, 776.)

2. A. SUBSESSILE, *Kunze, Analecta, p.* 29, *t.* 19. (Fendl. 305. Wright, 775.)

3. A. LINEATUM, *Kaulf. Enum. p.* 199. (Fendl. 304. Wright, 974, 977.)

Genus IX. POLYPODIUM, *L.*

§ I. EUPOLYPODIUM.

1. P. MARGINELLUM, *Swartz, Fl. Ind. Occ.* 1631. Mecosorus marginellus, *Klotzsch in Lin.* 20, *p.* 405. (Fendl. 256.)

2. P. JUNGERMANNIOIDES, *Klotzsch in Lin.* 20, *p.* 373. (Fendl. 257.)

3. P. SERRULATUM, *Metten. Fil. Lips. p.* 30. Xiphopteris serrulata, *Kaulf. Enum. p.* 85. (Fendl. 356. Wright, 780.)

4. P. TRICHOMANOIDES, *Swartz.* (Wright, 811, 1049.)

5. P. TRUNCICOLA, *Klotzsch in Lin.* 20, *p.* 374. (Fendl. 211, 211 β, 465.)

6. P. MONILIFORME, *Cav.; Metten. Polypod. p.* 41. P. subcrenatum, *Hook. Ic. Pl. t.* 719. (Fendl. 406. Wright, 1050.)

7. P. PILOSISSIMUM, *Martens & Galeotti, Fil. Mex. p.* 39, *t.* 9. (Fendl. 219.)

8. P. APICULATUM, *Kunze* ex *Klotzsch in Lin.* 20, *p.* 378. (Fendl. 218.)

9. P. FLABELLIFORME, *Lam.; Metten. Polypod. p.* 46. P. Tovarense, *Klotzsch, l. c. p.* 374. (Fendl. 207.)

10. P. SUBTILE, *Kunze* ex *Klotzsch, l. c. p.* 375. (Fendl. 349.)

11. P. SENILE, *Fée, Mém.* 7, *p.* 60, *t.* 25. P. flaccidum, *Metten.!* (Fendl. 209.)

12. P. ELASTICUM, *Bory; Metten. Polypod. p.* 47. (Fendl. 208, 348. Wright, 1018. Schott, 16.) (No. 208 = P. monosorum, *Moritz*, n. 1018 = sp. ignota, fide Mettenii.)

13. P. CULTRATUM, *Willd.; Metten. Polypod. p.* 47! (Fendl. 210.)

14. P. TENUIFOLIUM, *H.B.K.* P. camptoneuron, *Fée, Gen. p.* 237, *Iconogr. p.* 60, *t.* 23. (Wright, 809.)

15. P. LEPTOPHYLLUM, *Moritz; Metten. in litt.* (Fendl. 217.)

16. P. LANIGERUM, *Desv.; Metten. Pol. p.* 48. (Fendl. 212.)

17. P. FUNICULUM, *Fée, Iconogr. p.* 12, *t.* 18. (Wright, 807.)

18. P. PENDULUM, *Swartz; Schkuhr, Fil. p.* 12, *t.* 11. (Fendl. 350.)

19. P. SUSPENSUM, *L.* P. arcuatum, *Moritz, mscr.* (Fendl. 213, 213 β, 467. Wright, 808, 810.)

20. P. RADICALE, *Moritz; Metten!* P. difficile, *Moritz*, vix diversa. (Fendl. 215, 216.)

21. P. PECTINATUM, *L.* P. Plumula, *Willd. Sp. Pl.* 5, *p.* 178, forma juvenilis hujus videtur. (Wright, 806, 1017; 1051, pinnis dilatatis laciniatisque more Pol. vulgaris, var. Cambrici.) (Ex Mettenio, n. 806 = P. Plumula; n. 1017 = P. Otites; n. 1051 = sp. ignota.)

22. P. PARADISEÆ, *Langsd. & Fisch. Ic. Fil. p.* 11, *t.* 11. (Fendl. 220 β, 221, 221 γ.)

23. P. CONSIMILE, *Metten.* sp. nov. describenda. (Fendl. 220.)

24. P. MORITZIANUM, *Link. Sp. Fil. p.* 136; *Metten!* (Fendl. 214.)

25. P. SORORIUM, *H.B.K.* (Fendl. 422. Wright, 805.)

26. P. SUBPETIOLATUM, *Hook. Ic. Pl. t.* 391 & 392. (Fendl. 254.)

27. P. KARWINSKIANUM, *Al. Braun; Metten. Pol. p.* 66. (Fendl. 245.)

28. P. SPORADOLEPIS, *Kunze*, var. *β. Metten. Polypod. p.* 67. (Fendl. 246.)

§ II. GONIOPHLEBIUM.

29. P. INCANUM, *Swartz.* (Fendl. 253. Wright, 795.)

30. P. THYSSANOLEPIS, *Al. Braun; Metten. Pol. p.* 70. (Fendl. 252.)

31. P. LEPIDOPTERIS, *Kunze in Lin.* 13, *p.* 132. P. sepultum, *Kaulf. Enum.* 104. Lepicystis sepulta, *J. Smith in Lond. Jour. Bot.* 1, *p.* 195. (Fendl. 343.)

32. P. LASIOPUS, *Klotzsch, l. c. p.* 293. (Fendl. 244.)

33. P. LATIPES, *Langsd. & Fisch. Ic. Fil. p.* 10, *t.* 10. P. harpeodes, *Link. Fil. Sp. p.* 127. (Fendl. 242, 239, 341.)

34. P. LORICEUM, *L.*; *Metten. Fil. Lips. p.* 32, *t.* 23, *f.* 7–9. (Fendl. 343? 353. Wright, 827.)

35. P. CHNOODES, *Spreng. Syst.* 4, *p.* 53. (Fendl. 238. Wright, 1019.)

36. P. NERIIFOLIUM, *Swartz; Schkuhr, Fil. p.* 14, *t.* 15. P. gladiatum, *Kunze in Lin.* 9, *p.* 45. (Filix Cubensis vix a Brasiliensi diversa, soris magis impressis pinnisque falcatis longioribus tantum recedens.) (Fendl. 352, 415, 471. Wright, 804.)

37. P. FRAXINIFOLIUM, *Jacquin; Metten. Fil. Lips. p.* 33. (Fendl. 234, 236, 237.)

§ III. CAMPYLONEURUM.

38. P. ANGUSTIFOLIUM, *Swartz, Syn. p.* 28. (Fendl. 224. Wright, 797.)

39. P. TÆNIOSUM, *Willd. Sp. Pl.* 5, *p.* 155. (Fendl. 225, 226. Wright, 800.)

40. P. VEXATUM. Campyloneuron Cubense, *Fée, Gen. p.* 259, *Iconogr. p.* 14, *t.* 3. (Wright, 801.) — Mettenius (*Polypod. p.* 82) hasce tres in unam (*P. tæniosum*) colligit; an recte? Fée per contra (*Iconogr. p.* 128) distinctissimas affirmat.

41. P. FASCIALE, *Willd. l. c. p.* 156. (Fendl. 228, 228 β, 229, 230, 409. Schott, 22.)

42. P. REPENS, *Swartz; Metten. Fil. Lips. p.* 34, *t.* 24. (Fendl. 227. Wright, 1021.)

43. P. COSTATUM, *Kunze in Lin.* 9, *p.* 28. (Wright, 802.)

44. P. DECURRENS, *Raddi, Nov. Gen. p.* 23, *t.* 33. (Fendl. 231.)

45. P. FENDLERI (sp. nov.): elatum, glabrum; frondibus simplicibus vel plerumque pinnatis stipite stramineo elongato insidentibus; pinnis 7–11 alternis late ellipticis vel oblongis basi superiori cuneatis inferiori breve decurrentibus chartaceis subnitidis anguste cartilagineo-marginatis; costis costulisque utrinque elevatis; venulis conspicuis arcus Campyloneuri 12–15 efficientibus, arcubus radios plerumque liberos apice soriferos emittentibus, maculis versus marginem frondis sæpe divisis. — Rhizoma repens, digiti crassum, vix paleaceum. Stipes stramineus, validus, bi–tripedalis, basi paleis ovatis fugacibus tectus. Frons ovata, stipiti æquilonga. Pinnæ utrinque 3–5, terminalis æqualis, pedalis, 3–4 poll. latæ, obtusæ vel brevi-acuminatæ. Forma frondis Chrysodium acuminatum refert. Frondes plantæ junioris simplices, 6–10-pollicares. Pro varietate *P. decurrentis* ducit Mettenius (in litt.) qui jam in hortis hospitatum atque a Kunzeo *P. venustum* dicatum significat. Sed nomen *venustum* olim est appropriatum in genere Polypodio. (Vid. *Metten. Polypod. p.* 49.) (Fendl. 410.)

§ IV. PLEOPELTIS.

46. P. ELONGATUM, *Metten. Pol. p.* 88. Grammitis elongata, *Swartz.* Pleopeltis angustifolia, *Eaton in Sill. Jour. n. ser.* 28, *p.* 198. (Wright, 796.)

47. P. LEPIDOTUM, *Willd.; Metten. l. c. p.* 88. (Fendl. 249, 250.)

48. P. LEUCOSPORUM, *Klotzsch in Lin.* 20, *p.* 404. (Fendl. 251.)

49. P. PERCUSSUM, *Cav. Præl.* 1801, *p.* 243; *Hook. Fil. Exot. t.* 59. Pleopeltis percussa, *Hook. & Grev. Ic. Fil. t.* 67. (Fendl. 421, 464.)

§ V. CRASPEDARIA.

50. P. CAYENNENSE, *Desv. Jour. Bot.* 5, *p.* 257; *Metten. Pol. p.* 93. (Prope Gatum, coloniam Panamensem, Hayes, 26.)

51. P. PILOSELLOIDES, *L. Metten. l. c.* (Fendl. 354, 419. Wright, 798, planta genuina.)

52. P. VACCINIFOLIUM, *Langsd. & Fisch. Ic. Fil. p.* 8, *t.* 7. (Fendl. 248.)

§ VI. PHLEBODIUM.

53. P. SERPENS, *Swartz, Syn. p.* 26. (Wright, 799.)

54. P. SALICIFOLIUM, *Willd. Sp. Pl.* 5, *p.* 149. (Fendl. 420. Wright, 1023. Hayes, 16.)

55. P. AUREUM, *L.* (Fendl. 417.)

56. P. AREOLATUM, *H.B.K.* P. aureum, *Eaton, in Sill. Jour. l. c.* (Fendl. 241. Wright, 803, fide Metten!)

§ VII. PHYMATODES.

57. P. CRASSIFOLIUM, *L.; Metten. l. c.* p. 109. (Fendl. 220. Wright, 1022.)

Var. *β. Metten. l. c.* P. porrectum, *Willd. l. c. p.* 161. (Fendl. 222.)

Var. *γ. Metten. l. c.* P. acrosorum, *Kunze in Lin.* 20, *p.* 39. (Hayes, 18. Schott, 27.)

Genus X. GYMNOGRAMME, *Desv.*

§ I. CEROPTERIS.

1. G. TRIFOLIATA, *Desv. in Berl. Mag.* 5, p. 305; *Kaulf. Enum. p.* 72. (Fendl. 297. Wright, 779.)

2. G. SULPHUREA, *Desv.; Lowe, Fil.* 1, *p.* 11, *t.* 5. (Wright, 778.)

3. G. TARTAREA, *Desv.; Metten. Fil. Lips. p.* 41. (Fendl. 299. Wright, 777, pro parte.)

4. G. CALOMELANOS, *Desv.; Metten. l. c.* (Fendl. 298. Wright, 777, pro parte.)

5. G. PULCHELLA, *Linden, in Hook. Fil. Exot. t.* 74. (Fendl. 357.)

§ II. EUGYMNOGRAMME.

6. G. LEPTOPHYLLA, *Desv.; Lowe, Fil.* 1, *p.* 17, *t.* 7. (Wright, 860.)

7. G. LASERPITIIFOLIA, *Kunze in Bot. Zeit.* 3, *p.* 285? (Fendl. 359.)

8. G. REFRACTA, *Kunze in Lin.* 20, *p.* 410. (Fendl. 300.)

§ III. Neurogramme.

9. G. rufa, *Desv.; Lowe, Fil.* 1, *p.* 13, *t.* 6. (Fendl. 302.)

§ IV. Hemionitis.

10. G. palmata, *Link. Hort. Berol.* 2, *p.* 49. Hemionitis palmata, *L.* (Fendl. 303. Wright, 774.)

Genus XI. MENISCIUM, *Schreb.*

1. M. sorbifolium, *Willd.; Langsd. & Fisch. Ic. Fil. p.* 6, *t.* 4. (Wright, 781.)
2. M. reticulatum, *Swartz, Syn. p.* 19. (Fendl. 232. Wright, 782.)

Genus XII. NOTHOLÆNA, *R. Br.*

1. N. ferruginea. Gymnogramme ferruginea, *Kunze in Lin.* 9, *p.* 34. Nothochlæna crassifolia, "*Moore & Houlston*"; *Lowe, Fil.* 1, *p.* 35, *t.* 14. — Frondes pinnatæ, nunc basi bipinnatisectæ; pinnis oblongis vel oblongo-lanceolatis obtusis integris crenatis auriculatis vel pinnatisectis supra glabris infra pilis fulvis stellatis vestitis atque massa alba pulverulenta obductis, quam ob rem frondes primum subtus albæ, maturantes pulvere amisso fulvæ videntur. (Wright, 776 pro parte, 1048.)

Genus XIII. CHEILANTHES, *Swartz.*

1. Ch. Moritziana, *Kunze in Lin.* 23, *p.* 307. (Fendl. 65.)
2. Ch. elongata, *Willd.; Metten. Cheil. p.* 33. (Wright, 887.)
3. Ch. paupercula, *Metten. Fil. Lips. p.* 52. Hypolepis paupercula, *Hook. Sp. Fil.* 2, *p.* 73, *t.* 88. (Wright, 964.)
4. Ch. radiata, *J. Smith in Hook. Jour. Bot.* 4, *p.* 159. Adiantum radiatum, *L.* (Fendl. 67. Wright, 963.)

Genus XIV. ADIANTUM, *L.*

1. Ad. macrophyllum, *Swartz; Hook. Fil. Exot. t.* 55. (Fendl. 88. Wright 874. Schott, 56.)
2. Ad. Seemanni, *Hook. Sp. Fil.* 2, *p.* 5, *t.* 81. (Schott, 68.)
3. Ad. obliquum, *Willd.; Hook. Sp. Fil.* 2, *p.* 8, *t.* 79. (Fendl. 469. Wright, 987. Schott, 66.)
4. Ad. Kaulfussii, *Kunze in Lin.* 21, *p.* 221. (Fendl. 87, 469 β. Schott, 69.)
5. Ad. lunulatum, *Burm.; Hook. & Grev. Ic. Fil. t.* 104. (Fendl. 82.)
6. Ad. dolabriforme, *Hook. Ic. Pl. t.* 191. (Fendl. 81.)

7. Ad. pulverulentum, *L.; Hook. Sp. Fil.* 2, *p.* 17. (Fendl. 86. Wright, 879, anno 1859 lecta.)

8. Ad. villosum, *L.; Hook. Sp. Fil.* 2, *p.* 18. (Fendl. 85, 364. Wright, 882.)

9. Ad. obtusum, *Desv.; Hook. l. c. p.* 19; *Hook. & Grev. Ic. Fil. t.* 188. (Fendl. 84.)

10. Ad. prionophyllum, *H.B.K.; Hook. l. c.* 2, *p.* 21. A. tetraphyllum, *Willd.; Metten.* (Fendl. 83. Wright, 986. Schott, 64.)

11. Ad. intermedium, *Swartz; Hook. Sp. Fil.* 2, *p.* 25. (Fendl. 468. Schott, 67.)

12. Ad. trapeziforme, *L.; Hook. Sp. Fil.* 2, *p.* 33. Ad. pentadactylon, *Hook. & Grev. Ic. Fil. t.* 98. (Wright, 875.)

13. Ad. patens, *Willd.; Hook. Sp. Fil.* 2, *p.* 29, *t.* 87. (Fendl. 79.)

14. Ad. Capillus-Veneris, *L.* (Fendl. 78, 496, 68? Wright, 988.)

15. Ad. Æthiopicum, *L.; Hook. Sp. Fil.* 2, *p.* 37, *t.* 77. (Fendl. 71.)

16. Ad. tenerum, *Swartz; Hook. Sp. Fil.* 2, *p.* 45. (Fendl. 69, 70. Wright, 989.)

17. Ad. fragile, *Swartz; Hook. Ic. Pl. t.* 965. (Wright, 878.)

18. Ad. concinnum, *H.B.K. Nov. Gen.* 1, *p.* 7 & 17, *t.* 668. (Fendl. 73, 74, 75, 76, 77. Wright, 877.)

19. Ad. sessilifolium, *Hook. Sp. Fil.* 2, *p.* 44, *t.* 85. (Fendl. 72.)

20. Ad. cristatum, *L.; Hook. Sp. Fil.* 2, *p.* 46. (Wright, 879 anno 1856 lecta, 990, 994.)

21. Ad. microphyllum, *Kaulf. Enum. p.* 204. (Wright, 992.)

22. Ad. Kunzeanum, *Klotzsch in Lin.* 8, *p.* 555. (Wright, 993.)

23. Ad. Cubense, *Hook. Sp. Fil.* 2, *p.* 8, *t.* 73. — Var. pinnis duabus infimis elongatis iterum pinnatis. Proxima Ad. cristato, sed fronde laxa nec rigida, pinnulis terminalibus pinnarum inferiorum dilatato-cuneatis obtusis soriferis, pinnulis omnibus membranaceis siccitate explanatis, colore viridi-cærulescentibus, satis distincta. (Wright, 991.)

24. Ad. polyphyllum, *Willd. Sp. Pl.* 5, *p.* 454. Ad. cardiochlæna, *Kunze; Hook. Sp. Fil.* 2, *p.* 50, *t.* 83. (Fendl. 80.)

Genus XV. PELLÆA, *Link.*

1. P. geraniifolia, *Fée, Gen. p.* 130. Pteris geraniifolia, *Raddi; Hook. Ic. Pl. t.* 915. (Fendl. 92.)

2. P. flexuosa, *Link. Fil. Sp. p.* 60. Allosorus flexuosus, *Kunze, Fil. p.* 46, *t.* 23. (Fendl. 89.)

3. P. decomposita, *Hook. Sp. Fil.* 2, *p.* 151, *t.* 119. Allosorus decompositus, *Mart. & Gal. Fil. Mex. p.* 48, *t.* 10. (Fendl. 90, 404. Cheilanthes marginata, *H.B.K.* ex *Metten.*)

Genus XVI. ONYCHIUM, *Kaulf.*

1. O. STRICTUM, *Kunze, Fil.* 2, *p.* 11; *Hook. Cent. Fil.* 2, *t.* 32. (Wright, 858, 859.)

Genus XVII. PTERIS, *L.*

§ I. EUPTERIS.

1. PT. LONGIFOLIA, *L.*; *Hook. Sp. Fil.* 2, *p.* 157. (Wright, 871.)

Var. *γ.* pinnis anguste linearibus rigidis, *Hook. l. c.* (Wright, 981. Fendl. 105.)

2. PT. MUTILATA, *L.*; *Hook. l. c. p.* 164, *t.* 131. (Wright, 869.)

3. PT. LACINIATA, *Willd.*; *Hook. l. c. p.* 176, *t.* 132. (Fendl. 100. Wright, 883.)

4. PT. QUADRIAURITA, *Retz*; *Hook. l. c. p.* 179, *t.* 134. P. repandula, *Link*; *Metten.* (Fendl. 103. Wright, 983.)

5. PT. DEFLEXA, *Link. Hort. Berol.* 2, *p.* 30; *Hook. l. c. p.* 190. (Fendl. 101, 102?)

§ II. ORNITHOPTERIS.

6. PT. AQUILINA, *L.*; *Hook. l. c. p.* 196. Var. CAUDATA, *Hook.* Pt. caudata, *L.* (Wright, 872.)

Var. ARACHNOIDEA. Pt. arachnoidea, *Kaulf. Enum. p.* 190. (Wright, 985, segmentis ultimis angustis valde approximatis. Fendl. 104.) (Speciem distinctam affirmat Mettenius, *Fil. Lips. p.* 60.)

7. PT. SCALARIS, *Moritz*; *Hook. l. c. p.* 200, *t.* 121; *Metten. Farngatt.* 3, *p.* 9, *t.* 16. (Fendl. 94.)

§ III. HETEROPHLEBIUM.

8. PT. GRANDIFOLIA, *L.* Heterophlebium grandifolium, *Fée, Gen. p.* 139, *t.* 11. (Fendl. 96. Wright, 982.)

§ IV. CAMPTERIA.

9. PT. CILIARIS (sp. nov.): glabra; caudice brevi repente paleis ovato-lanceolatis medio nigris margine lato pallide fusco denticulatis obsesso; stipiti gracili nitido stramineo basi ebeneo; lamina ovata pinnata; pinnis 4–6-jugis distantibus sub-oppositis, inferioribus bipinnatisectis, mediis pinnatisectis; segmentis paucis remotis anguste linearibus rectis basi longe decurrentibus apice serrato acuminatis; venulis furcatis liberis vel plerumque areolas costulares bi–tri-radiatas efformantibus; involucro lato membranaceo eleganter ciliato in alam rachidis partialis decurrente.—Stipes 7–12 pollices longus: lamina 8–12 pollices longa, 6–9 poll. lata. Pt. leptophyllæ similis, sed segmentis linearibus indivisis et involucro ciliato abunde distincta. (Wright, 868.)

§ V. Litobrochia.

10. Pt. sagittifolia, *Raddi, Syn. Fil. Bras. n.* 106; *Hook. Fil. Exot. t.* 39. Doryopteris sagittifolia, *J. Smith.* (Fendl. 366.)

11. Pt. pedata, *L.; Hook. Fil. Exot. t.* 34. Doryopteris pedata, *J. Smith; Fée, Gen. p.* 133. (Fendl. 91. P. palmata, *Willd.* ex *Metten.* Wright, 867.)

12. Pt. denticulata, *Swartz; Hook. & Grev. Ic. Fil. t.* 28 (excl. syn.); *Hook. Sp. Fil.* 2, *p.* 215. (Wright, 870.)

13. Pt. Kunzeana, *Agardh, Pteris, p.* 62. (Fendl. 365. Wright, 984. Schott, 59.)

14. Pt. elata, *Agardh, l. c.* 63. (Fendl. 95.)

15. Pt. aculeata, *Swartz; Hook. Sp. Fil.* 2, *p.* 224. (Fendl. 97. Wright, 873.)

16. Pt. podophylla, *Swartz; Hook, l. c. p.* 227. Litobrochia camptocarpa, *Fée, Gen. p.* 137. (Fendl. 98, 99.)

17. Pt. incisa, *Thunb. Fil. Cap. p.* 733; *Hook. l. c. p.* 230. P. vespertilionis, *Labill. et auct.* (Fendl. 93.)

Trib. III. ASPLENIACEÆ.

Genus XVIII. LOMARIA, *Willd.*

1. L. attenuata, *Willd. Sp. Pl.* 5, *p.* 290; *Hook. Sp. Fil.* 3, *p.* 6. L. onocleoides, *Spreng.; Hook. l. c. p.* 9, *t.* 146. L. decrescens, *Fée, Iconogr. p.* 24, *t.* 9. (Fendl. 308. Wright, 864.)

2. L. Plumieri, *Desv.; Hook. l. c. p.* 7. (Fendl. 309.)

3. L. L'Herminieri, *Bory; Kunze, Fil. p.* 173, *t.* 73. (Fendl. 310.)

4. L. procera, *Spreng. Syst.* 4, *p.* 65; *Hook. l. c. p.* 22. (Fendl. 118, 119, 120, 122.)

5. L. Magellanica, *Desv.; Hook. l. c. p.* 26. (Fendl. 340.)

6. L. biserrata, "*Mert. & Lind.*"; *Hook. l. c. p.* 19. Plagiogyria biserrata, *Metten. Farngatt.* 2, *p.* 7, *t.* 15. (Fendl. 325, nec 335, quod Hook. l. c.)

Genus XIX. BLECHNUM, *L.*

1. B. occidentale, *L.; Hook. Sp. Fil.* 3, *p.* 50. (Fendl. 106, 107, 108, 109. Wright, 863.)

2. B. longifolia, *H.B.K.; Hook. l. c. p.* 49, *t.* 154. (Fendl. 113, 114, 115, etiam 111, 112, pinnis latioribus. Schott, 15.)

3. B. Fendleri, *Hook. l. c. p.* 49, *t.* 158. (Fendl. 116.)

4. B. polypodioides, *Raddi, Nov. Gen. p.* 53, *t.* 60. (Fendl. 110, 110 β.)

5. B. VOLUBILE, *Kaulf. Enum. p.* 159; *Hook. l. c. p.* 63. Salpichlæna volubilis, *J. Smith in Hook. Jour. Bot.* 4, *p.* 168. (Fendl. 117.)

Genus XX. ASPLENIUM, *L.*

§ I. EUASPLENIUM.

1. A. SERRATUM, *L.; Hook. Fil. Exot. t.* 70. (Fendl. 489. Wright, 837. Hayes, 39.)

2. A. OLIGOPHYLLUM, *Kaulf. Enum.* 166. (Fendl. 326.)

3. A. ANISOPHYLLUM, *Kunze in Lin.* 10, *p.* 511; *Hook. Sp. Fil.* 3, *p.* 111, *t.* 166. (Wright, 845.)

4. A. SALICIFOLIUM, *L.; Hook. Sp. Fil.* 3, *p.* 112. (Fendl. 411. Wright, 841. Schott, 49.)

5. A. HASTATUM, *Klotzsch in Lin.* 23, *p.* 305; *Hook. l. c. p.* 116. *t.* 172. (Fendl. 331, 331 *β*. 144, pro parte.)

6. A. AURICULATUM, *Swartz; Hook. l. c. p.* 118, *t.* 171. (Wright, 848 pro parte, 1028.)

7. A. RIPARIUM, *Liebmann, Fil. Mex. p.* 92; *Hook, l. c. p.* 119, *t.* 179. (Fendl. 131.)

8. A. ALATUM, *H.B.K.; Hook. & Grev. Ic. Fil. t.* 137. (Fendl. 145. Schott, 44.)

9. A. RHIZOPHORUM, *L.; Hook. Sp. Fil.* 3, *p.* 122, *t.* 187. (Fendl. 125, 126, 127, 140, 434. Wright, 850, 851, 1041.)

10. A. ERECTUM, *Bory in Willd. Sp. Pl.* 5, *p.* 510. *Hook. Sp. Fil.* 3, *p.* 126. (Fendl. 135, 137, 138, 433. Wright, 849, 1024.)

11. A. DENTATUM, *L.; Hook. & Grev. Ic. Fil. t.* 72. (Wright, 853.)

12. A. LÆTUM, *Swartz; Hook. l. c. p.* 133, *t.* 173. A. Schkuhrianum, *Presl*, ex *Metten.!* (Fendl. 136, 139 *β*. Wright, 1026, 1027.)

13. A. FIRMUM, *Kunze in Bot. Zeit.* 3, *p.* 283; *Hook. l. c. p.* 134, *t.* 174. (Fendl. 139, 143, 143 *β*. Wright, 848. Schott, 51.)

14. A. TRICHOMANES, *L.*, var. MAJUS, *Hook. l. c. p.* 137. (Wright, 1042.)

15. A. MONANTHEMUM, *L.; Metten. Fil. Lips. p.* 74, *t.* 9. (Fendl. 134.)

16. A. FORMOSUM, *Willd. Sp. Pl.* 5, *p.* 329; *Hook. Fil. Exot. t.* 16. (Fendl. 133. Wright, 854.)

17. A. BISSECTUM, *Swartz; Hook. Sp. Fil.* 3, *p.* 151, *t.* 192. (Wright, 852.)

18. A. SERRA, *Langsd. & Fisch. Ic. Fil. p.* 16, *t.* 19. (Fendl. 155, 332, 333. Wright, 840.)

19. A. DIMIDIATUM, *Swartz; Hook. Sp. Fil.* 3, *p.* 159. (Wright, 842.)

20. A. EROSUM, *L.; Metten. Asplen. p.* 157. (Wright, 843, 1043.)

21. A. FURCATUM, *Thunb. Prodr. p.* 172; *Metten. Aspl. p.* 159. A. præmorsum, *Swartz, Syn. p.* 83. A. Canariense, *Willd. l. c. p.* 339. (Fendl. 156, 157. Wright, 1031.)

22. A. CUNEATUM, *Lam.; Hook. Sp. Fil.* 3, *p.* 168. (Wright, 1030. Exemplaria vix ab Aspl. laserpitiifolio diversa.)

23. A. AURITUM, *Swartz, Fl. Ind. Occ.* 3, *p.* 1616; *Metten. Aspl.* 103. (Fendl. 141, 142. Wright, 1025. Schott, 46.)

24. A. FRAGRANS, *Swartz, Fl. Ind. Occ.* 3, *p.* 1612; *Metten. Aspl.* 104. A. fœniculaceum, *H.B.K.* (Fendl. 368. Wright, 857, frondes A. delicatuli, *Pr.* intermixtæ, ex *Hook.*)

25. A. PUMILUM, *Swartz, Fl. Ind. Occ.* 3, *p.* 1610; *Hook. Sp. Fil.* 3, *p.* 174. (Fendl. 130. Wright, 861.)

26. A. SQUAMOSUM, *L.; Hook. Sp. Fil.* 3, *p.* 186, *t.* 210. (Fendl. 132.)

§ II. DAREA.

27. A. RUTACEUM, *Metten. Aspl. p.* 129; *Hook. Cent. Fil.* 2, *t.* 34. (Fendl. 123.)

28. A. CICUTARIUM, *Swartz; Metten. Fil. Lips. t.* 13. (Fendl. 124. Wright, 855.)

29. A. MONTEVERDENSE, *Hook. Sp. Fil.* 3, *p.* 195 *& Cent. Fil.* 2, *t.* 41. Vix satis diversa ab A. cicutario, cui speciei refert Mettenius in litt. (Wright, 856, 1029.)

§ III. HEMIDICTYUM.

30. A. MARGINATUM, *L., Hook. Fil. Exot. t.* 63. Hemidictyum marginatum, *Presl.* (Fendl. 167. Wright, 838.)

§ IV. DIPLAZIUM.

31. A. PLANTAGINEUM, *L.; Metten. Aspl. p.* 161. (Fendl. 154.)

32. A. CELTIDIFOLIUM, *Metten. Fil. Lips. p.* 75, *t.* 12; *Hook. Sp. Fil.* 3, *p.* 240. Diplazium celtidifolium, *Kunze in Bot. Zeit.* 3, *p.* 285. (Fendl. 152, 153.)

33. A. GRANDIFOLIUM, *Swartz, Prodr. p.* 130; *Hook. Sp. Fil.* 3, *p.* 241. (Fendl. 497. Wright, 846, 1037? Schott, 50.)

34. A. JUGLANDIFOLIUM, *Lam.; Hook. Sp. Fil.* 3, *p.* 242. Diplazium juglandifolium, *Swartz; Hook. Fil. Exot. t.* 100. (Fendl. 498.)

35. A. OTTONIS, *Klotzsch*, var. *β. Hook. Sp. Fil.* 3, *p.* 243. (Wright, 1036.)

36. A. STRIATUM, *L.; Hook. l. c. p.* 245. A. Shepherdi, *Spreng.* (Wright, 1035. Schott, 42.)

Var. CARACASANUM. Asplenium Caracasanum, *Willd.* (Fendl. 129, 129 *β.*)

Var. AURICULATUM. Diplazium auriculatum, *Kaulf. Enum. Fil. p.* 183. Asplenium arboreum, *Willd.; Hook. l. c. p.* 246. (Wright, 1034. Fendl. 128, 128 *β.*)

37. A. CUBENSE, *Hook. l. c. p.* 253, *t.* 207. — Præcedenti affinis, cujus forma juvenilis forsitan rectius habenda. (Wright, 1032, 1033.)

38. A. DUBIUM, *Metten. Asplen. p.* 187; *Hook. l. c. p.* 261. (Fendl. 146, 147, 436. Wright, 847, 1044, 1038, 1039.)

39. A. Klotzschii, *Metten. Fil. Lips. p.* 79; *Hook. l. c. p.* 263. Lotzea diplazioides, *Klotzsch & Karst. in Linnæa*, 20, *p.* 358. (Fendl. 148? 149.)

(Aliæ Diplazii species sunt Fendl. 150, 151, et Wright, 1045.)

§ V. Athyrium.

40. A. Martensii, *Kunze in Sill. Journ. ser.* 2, 6, *p.* 86. (Fendl. 405.)

Trib. IV. ASPIDIACEÆ.

Genus XXI. HYPOLEPIS, *Bernh.*

1. H. repens, *Presl. Tentamen Pterid. p.* 162. (Wright, 894.)
2. H. parallelogramma, *Hook. Sp. Fil.* 2, *p.* 65, *t.* 78. (Fendl. 66.)
3. H. Purdieana, *Hook. Sp. Fil.* 2, *p.* 69, *t.* 91. (Fendl. 64.)

Genus XXII. PHEGOPTERIS, *Fée.*

1. Ph. pteroidea, *Metten. Phegop. p.* 9. Polypodium pteroideum, *Klotzsch in Lin.* 20, *p.* 389. (Fendl. 206.)
2. Ph. cochleata, *Metten. l. c. p.* 11. Polypodium cochleatum, *Klotzsch in Lin.* 20, *p.* 388. (Fendl. 171.)
3. Ph. platyphylla, *Metten. l. c. p.* 12. Aspidium platyphyllum, *Willd. l. c. p.* 255. (Fendl. 175. Wright, 832.)
4. Ph. aspidioides, *Metten. Fil. Lips. p.* 82, *t.* 17. Gymnogramme aspidioides, *Kaulf. Enum. p.* 81. (Fendl. 306.)
5. Ph. rupestris, *Metten. Fil. Lips. p.* 82. Gymnogramme rupestris, *Klotzsch in Lin.* 20, *p.* 310. (Fendl. 307.)
6. Ph. rudis, *Metten. Fil. Lips. p.* 83. (Fendl. 158.)
7. Ph. decussata, *Metten. Fil. Lips. p.* 83, *t.* 17. Polypodium decussatum, *L.; Willd. l. c. p.* 204. (Fendl. 373.)
8. Ph. Tijuccana, *Fée, Gen. p.* 243. Polypodium Tijuccanum, *Raddi, Fil. Bras.* 25, *t.* 37. (Fendl. 198.)
9. Ph. tetragona, *Metten. Fil. Lips. p.* 84. Polypodium tetragonum, *Swartz, Syn. p.* 37. (Fendl. 196. Wright, 817.)
10. Ph. Megalodus, *Metten. Phegopt. p.* 24. Polypodium Megalodus, *Schkuhr, Fil. p.* 24, *t.* 19. (Fendl. 200.)
11. Ph. crenata, *Metten. Fil. Lips. p.* 84. Polypodium crenatum, *Swartz, Syn. p.* 37. (Fendl. 199.)

12. Ph. divergens, *Metten. Fil. Lips. p.* 83. Polypodium divergens, *Willd. Sp. Pl.* 5, *p.* 209. (Fendl. 205. Wright, 831.)

13. Ph. Portoricensis, *Fée, Gen. Fil. p.* 243 ex *Metten.* (Wright, 1000.)

14. Ph. sericea, *Metten.* (sp. nov.): caudice repente paleaceo; stipite gracili frondibusque sericeo-hirtis; frondibus subpellucidis ovatis acuminatis basi bipinnatis versus apicem pinnatifidis; pinnis infimis oppositis inæquilateris ovatis, pinnulis lateris inferioris majoribus elongatis pinnatifidis lateris superioris minoribus vix incisis; pinnis superioribus oblongo-ovatis pinnatifidis segmentis oblique-ovatis obtusis lateris superioris majoribus; venulis e costula pinnatis liberis simplicibus vel furcatis; soris in dorso venularum costulæ subapproximatis; sporangiis pilis hyalinis articulatis longissimis intermixtis. — Caudex crassitie pennæ corvinæ, paleis angustis rubiginosis vestitus. Stipes subpedalis, gracilis, sericeo-pubescens. Frondes semipedales, 3 – 4 pollices latæ, deltoideo-ovatæ, undique pilis albescentibus 6 – 8-articulatis sericeæ: segmenta ovata, obtusa vel acutiuscula, basi inferiori cuneata, superiori truncata et costæ parallela. Venulæ opacæ in parenchymate subpellucido evidentissimæ. Filix pulchella, a ceteris Phegopteridis speciebus plane diversa. (Wright, 1054.)

15. Ph. Karsteniana, *Metten. Phegop.* 30. (Fendl. 447.)

16. Ph. subincisa, *Fée, Gen.* 243. Polypodium subincisum, *Kaulf.; Martius, Ic. Crypt. Bras.* 89, *t.* 64. (Fendl. 202. Wright, 1012.)

Genus XXIII. ASPIDIUM, *Swartz.*

§ I. Fadyenia.

1. A. Fadyenii, *Metten. Fil. Lips. p.* 95, *t.* 23. Fadyenia prolifera, *Hook. Gen. t.* 53, *& Fil. Exot. t.* 36. Frondes interdum crenato-laciniatæ. (Wright, 844.)

§ II. Amblia.

2. A. juglandifolium, *Kunze,* ex *Klotzsch in Lin.* 20, *p.* 363. (Fendl. 233.)

§ III. Cyclopeltis.

3. A. semicordatum, *Swartz, Syn. p.* 45. Cyclopeltis semicordata, *J. Smith,* "*in Bot. Mag.* 72." (Fendl. 443. Wright, 1058.)

§ IV. Polystichum.

4. A. viscidulum, *Metten. Aspid. p.* 38. Aspidium glandulosum, *Hook. & Grev. Ic. Fil. t.* 140. (Wright, 1052.)

5. A. triangulum, *Swartz, Syn. p.* 44; *Hook. Fil. Exot. t.* 33. (Wright, 998.)

Var. laxum, *Hook. l. c.* Polystichum ilicifolium, *Fée, Gen. p.* 279; *Iconogr. p.* 21, *t.* 6. (Wright, 829.)

6. A. MUCRONATUM, *Swartz. Syn. p.* 43; *Metten. Aspid. p.* 41. A. trapezoides, *Swartz? Metten. in litt.* Rachis in nonnullis producta, apice radicans. (Wright, 828, 1057.)

7. A. MORITZIANUM, *Klotzsch in Lin.* 20, *p.* 367. (Fendl. 172, 173, 174. Wright, 1056?)

8. A. CORIACEUM, *Swartz, Syn. p.* 57; *Schkuhr. Fil. p.* 50, *t.* 50; *Metten. Fil. Lips. p.* 89. Filix Tasmaniâ, Capite B. S., Antillisque indigena. (Fendl. 499. Wright, 999.)

§ V. LASTREA.

9. A. MEXICANUM, *Presl. Rel. Hænk.* 1, *p.* 38. (Fendl. 168.)

10. A. DENTICULATUM, *Swartz, Syn. p.* 57. (Fendl. 170.)

11. A. EXCULTUM, *Metten. Aspid. p.* 69. (Fendl. 330.)

12. A. PUBESCENS, *Swartz, Syn. p.* 56. Nephrodium pubescens, *Hook. & Grev. Ic. Fil.* 162. (Wright, 815.)

13. A. MELANOSTICTUM, *Kunze in Lin.* 13, *p.* 148. A. melanochlamys, *Fée, Gen. p.* 294. (Wright, 830.)

14. A. CATOCARPUM, *Kunze in Lin.* 9, *p.* 95. (Fendl. 204.)

15. A. AMPLUM, *Metten. Aspid. p.* 74. (Wright, 1055, fide *Metten.*)

16. A. SANCTUM, *Metten. Aspid. p.* 76. Polypodium sanctum, *Swartz, Syn. p.* 39. (Wright, 814, 816, 885.)

17. A. OLIGOCARPUM, *H.B.K. Nov. Gen.* 1, *p.* 13. (Fendl. 176, 177, 179, 181, 416. Wright, 1013.)

18. A. PILOSULUM, *Klotzsch & Karst.* ex *Kunze in Lin.* 23, *p.* 229; *Metten. Fil. Lips. p.* 90 & 130. (Fendl. 178, 180, 182, 183, 184, 185.)

19. A. CONTERMINUM, *Willd. l. c. p.* 249. (Wright, 820.)

20. A. SPRENGELII, *Kaulf. Enum. p.* 239; *Metten. Aspid. p.* 81. (Fendl. 438. Schott, 6, 21. Wright, sine numero.)

21. A. PACHYRACHIS, "*Kunze herb.*"; *Metten. Aspid. p.* 83. (Fendl. 472.)

22. A. DIPLAZIOIDES, "*Moritz*"; *Metten. l. c.* (Fendl. 159.)

23. A. PATENS, *Swartz, Syn. p.* 49; *Metten. Fil. Lips. p.* 90. (Fendl. 190, 192.)

24. A. MACROURUM, *Kaulf. Enum. p.* 239; *Metten. Fil. Lips. p.* 87. (Wright, 1002 (*Metten.*), 819, 822. Fendl. 189, 473.)

25. A. CARIPENSE, *Metten. Fil. Lips. p.* 90. Polypodium Caripense, *Willd. l. c. p.* 202. (Fendl. 371.)

26. A. HIRTUM, *Swartz, Syn. p.* 56; *Metten. Aspid. p.* 114. Polypodium barbatum, *Kunze in Lin.* 9, *p.* 52. (Wright, 886.)

27. A. NEMOROSUM, *Willd. l. c. p.* 255. A. hirtum, *Metten. in litt.* (Wright, 1016.)

28. A. Wrightii, *Metten.* (sp. nov.): caudice repente paleaceo; stipitibus basi paleaceis erectis rachique breviter pilosis; frondibus lanceolatis pinnatifidis basi pinnatis; segmentis oblongis subfalcatis obtusis supra glabris subtus ad costam venulasque pubescentibus margine cartilagineo revolutis, infimis liberis remotis deflexis, superioribus contiguis ala lata confluentibus; venulis simplicibus utrinque ad costam 12–15, infimis binis ad sinum conniventibus, carina cartilaginea e sinu ad rachim procurrente; soris margini approximatis; indusio reniforme breviter setoso. — Stipites 2–6 pollicares, erecti, validi. Frondes rigidæ, subpedales, pollicem et sesquipollicem latæ. Sori in dorso venularum margini potius quam costulæ approximati. Indusia e cellulis serpentinis compacta, reniformia vel transverse oblonga, ad marginem setosa. Ab Aspidio Skinneri, *Hook*, cui affinis, statura majore, carina inter segmentis, aliisque notis satis diversa. (Wright, 824.)

29. A. lonchodes (sp. nov.): caudice repente elongato pennam anserinam crasso vix paleaceo; stipite fusco subpedali glabro vel supra pubescente; lamina subcoriacea rigida pedali vel sesquipedali utrinque ad costam costulamque pubescenti-hirta ceterum glabra lanceolata pinnata apice longo acuminato pinnatifida; pinnis 12–18-jugis utrinque sensim decrescentibus, infimis non deflexis, oblongis vel oblongo-lanceolatis crenatis vel pinnatifidis apice integro acuminatis; segmentis brevibus falcatis obtusis; venulis in quodam segmento utrinque 5–8, duabis infimis ad sinum conniventibus, carina e sinu fere ad costulam prominente; soris mediis inter marginem et costulam segmentorum; indusio reniformi dorso setoso persistente. — Similis sequenti, sed pinnis a medio laminæ ad basim sensim nec abruptim decrescentibus, inferioribus patentibus, satis distat. (Wright, 1007, 1008.)

30. A. deltoideum, *Swartz, Syn. p.* 49; *Metten. Aspid. p.* 93. Nephrodium deltoideum, *Desv.* (Wright, 823.)

31. A. Serra, *Swartz, Syn. p.* 47; *Metten. Fil. Lips. p.* 91. Nephrodium Serra, *Desv.* (Wright, 923, 1004.)

Var. laciniis lineari-oblongis subfalcatis acuminatis, *Metten. Aspid. p.* 93. Aspidium giganteum, *Moritz.* (Fendl. 188. Wright, 822 pro parte 1003.)

32. A. Fendleri (sp. nov.): elatum, amplum; stipite erecto valido fusco; fronde oblonga pinnata præter costas subtus puberulas glaberrima; pinnis multijugis oppositis patentissimis brevi-petiolatis lanceolatis crenato-pinnatifidis, laciniis subfalcatis obtusis ala latissima coadunatis; venulis curvatis 14–18 utrinque ad costulam, basalibus singulis e costa egredientibus mox conniventibus in venulam venulas quaternas quinasve accipientem et ad sinum procurrentem; soris in lacinia qualibet 20–30 confertis in seriem mediam inter costulam et marginem fere ad costam decurrentem; indusio reni-

formi (?) atro-purpureo glabro persistente siccitate corrugato. — Stipes tripedalis, pennam cygneam crassus, basi paleaceus ceterum glaber. Frondem integram non vidi. Pinnæ 6 – 9-pollicares, 15 – 20 lineas latæ; inferiores intervallo tripollicari disjunctæ; superiores magis approximati; terminali magna, cum duabus proximis basi coadunatæ. Segmenta membrana subpellucida e sinu versus costam decurrente conjuncta. Indusium maceratum reniforme videtur. Sori seriebus collocati, adjuvantibus concursu venularum et forma frondis Hemiteliam quandam simulant. (Fendl. 372.)

33. A. TETRAGONUM, *Metten. Aspid. p.* 95. (Fendl. 445. Wright, 1009, 1000. Schott, 12.)

34. A. SCOLOPENDRIOIDES, *Metten. Aspid. p.* 97. Var. INCISA, *Metten. l. c.* Aspidium stenopteris, *Kunze, Fil. t.* 120. (Wright, 825.)

Var. PINNATA, *Metten. l. c.* A. sclerophyllum, *Kunze.* (Wright, 1005, 1006.)

35. A. REPTANS, *Metten. Aspid. p.* 98. Var. CORDATA, *Metten. l. c.* Phegopteris cordata, *Fée, Gen. p.* 244; *Iconogr. p.* 13, *t.* 6. (Wright, 1014.)

Var. HASTÆFOLIUM, *Metten. l. c.* Polypodium hastæfolium, *Swartz; Hook. & Grev. Ic. Fil.* 203. (Wright, 812.)

Var. RADICANS, *Metten. l. c.* Polypodium reptans, *Swartz.* (Wright, 813.)

36. A. MOLLE, *Swartz, Syn. p.* 49. (Fendl. 191, 441, 473, 475. Wright, 818, 1001.)

§ VI. SAGENIA.

87. A. PEDATUM, *Desv.; Kunze, Fil.* 1, *p.* 179, *t.* 75. (Wright, 997.)

38. A. CICUTARIUM, *Swartz, Syn. p.* 51; *Metten. Aspid. p.* 117. (Wright, 995, 996, plantæ juveniles, vix semipedales, copiose soriferæ, 833.)

39. A. LATIFOLIUM, *Presl. Rel. Hænk.* 1, *p.* 30. (Schott, 32.)

§ VII. EUASPIDIUM.

40. A. MACROPHYLLUM, *Swartz, Syn. p.* 43, 239. (Fendl. 165, 166. Wright, 834. Schott, 5, 23, 39. Hayes, 43.) (Inter frondes quas ex Isthmo Panamensi misit Hayes unam in axillis pinnarum plurium proliferam frondulasque semipedales emittentem invenio.)

41. A. PLANTAGINEUM, *Griseb. Pl. Carib. p.* 138. Polypodium plantagineum, *Jacq.; Swartz, Syn. p.* 29. (Fendl. 412.)

42. A. TRIFOLIATUM, *Swartz, Syn. p.* 43; *Metten. Fil. Lips. p.* 95, *t.* 22. (Fendl. 164, 164 *β*. Wright, 835. Schott, 38, 39.)

43. A. DRACONOPTERUM (sp. nov.): stipite elongato paleaceo; fronde ampla e basi cordata ambitu ovata glabra pinnatifida; segmentis 7 – 9 oppositis ovato-oblongis caudato-acuminatis leviter sinuatis ala lata confluentibus, infimis brevioribus oblique

ovatis latere inferiore rotundatis superiore rectis, superioribus late oblongis, terminali duplo vel triplo majore latissime lanceolato; nervis secundariis curvatis, venulis reticulatis, maculis primariis latissimis sub-tetragonis utrinque ad costam 7 – 9-seriatis, maculis secundariis numerosis appendiculatis; soris plerumque apice venulæ insidentibus inter nervis secundariis 6 – 8-seriatis, indusiis . . . . . — Stipes pedalis, fuscus, versus basin paleis angustis fuscis obsessus. Frondes sesqui – bipedales, pedem latæ, chartaceo-membranaceæ, glabræ. Segmenta 3 – 4-juga, ala 6 – 12 lineas lata confluentia, inferiora remota 6 – 7 pollices longa 2 poll. lata, superiora tertiâ parte majora, terminale pedale, poll. 4 latum, omnia leviter sinuata, anguste acuminata. Anastomosis venarum pæne A. macrophylli. Sori in maculo quodam primario 15 – 30. Indusia ignota ætate delapsa. A. alati, *Wall.* haud dissimile, sed ala stipitis in illa specie conspicua omnino deest. Prope *Turbo* in sinu *Urabá*, Novæ Grandæ, coll. A. Schott, no. 19.

Genus XXIV. OLEANDRA, *Cav.*

1. O. NODOSA, *Presl. Tent. p.* 78. Aspidium nodosum, *Willd. l. c. p.* 211. (Wright, 836.)

TRIB. V. DAVALLIACEÆ.

Genus XXV. DIDYMOCHLÆNA, *Desv.*

1. D. LUNULATA, *Desv. Ann. Lin.* 6, *p.* 282. D. sinuosa, *Desv.; Martius, Ic. Crypt. Bras.* 95, *t.* 28, 29. (Fendl. 160. Wright, 862.)

Genus XXVI. NEPHROLEPIS, *Schott.*

1. N. EXALTATA, *Schott, Gen. Fil.* (Fendl. 162. Wright, 826.) (Ex Mettenio, no. 162 ad N. occidentalem, *Kunze*, no. 826 ad N. sesquipedalem, *Presl*, pertinent.)
2. N. TUBEROSA, *Presl. Tent. p.* 79. (Fendl. 161.)
3. N. PUNCTULATA, *Presl. l. c.* (Wright, 1011.)

Genus XXVII. DAVALLIA, *Smith.*

1. D. INÆQUALIS, *Kunze; Hook. Sp. Fil.* 1, *p.* 180. (Fendl. 375.)
2. D. POLYPODIOIDES, *Don. Prod. Fil. Nep. p.* 10; *Hook. l. c. p.* 181. Microlepia Antillarum, *Metten.!* (Wright, 896.)
3. D. SACCOLOMA, *Spreng. Syst.* 4, *p.* 119. Saccoloma elegans, *Kaulf. Enum. p.* 224, *t.* 1. (Fendl. 376.)

4. D. clavata, *Swartz, Syn. p.* 133. Microlepia venusta, *Metten.* (Wright, 961.)

5. D. aculeata, *Swartz, Syn. p.* 134. (Wright, 898, 960.)

6. D. uncinella, *Kunze, Fil.* 2, *p.* 96, *t.* 140. (Wright, 899.)

7. D. Lindeni, *Hook. Sp. Fil.* 1, *p.* 193, *t.* 56. (Fendl. 62.)

Genus XXVIII. LINDSÆA, *Dryand.*

§ I. Eulindsæa.

1. L. trapeziformis, *Dry. ; Hook. Sp. Fil.* 1, *p.* 214. (Fendl. 378. Wright, 976, pro parte. Schott, 54.)

2. L. horizontalis, *Hook. Sp. Fil.* 1, *p.* 214, *t.* 62. (Wright, 976, pro parte.)

3. L. quadrangularis, *Raddi, Nov. Gen. p.* 55, *t.* 74. (Fendl. 63, 63 *β*, 380.)

4. L. stricta, *Dry. ; Hook. l. c. p.* 216. L. elegans, *Hook. Ic. Pl. t.* 98. (Fendl. 377, 479.)

§ II. Dictyoxiphium.

5. L. Panamensis, *Metten. Fil. Lips. p.* 105. *Hook. Fil. Exot. t.* 54. Dictyoxiphium Panamense, *Hook. Gen. t.* 62. (Schott, 60. Hayes, 46.)

6. L. (Dictyoxiphium) Michleriana (sp. nov.): erecta, glabra; stipite elongato gracili parce paleaceo, fronde membranacea ampla ovato-lanceolata basi subcordata vix decurrente pinnatifida vel ima basi pinnata medio lobata apice sinuata; laciniis latis oblongis obtusiusculis; venulis anastomosantibus, areolis appendiculatis costalibus elongatis; soris intramarginalibus interruptis oblongis vel linearibus. — Frondes 12 – 15 pollices longæ, basi pinnatæ, pinnæ 3 – 5 pollices longæ pollicem latæ, infra medium pinnato-lobatæ, supra medium latissime lineares margine undulato. Dispositio venarum L. Panamensis simillima, sed laxior et (fronde aliquid tenuiore) oculo evidentior. Indusium tenue, interruptum, non marginem frondis tegens. Dicata in honore *Lieut. N. Michler, U. S. A.*, præfecto explorationis ad fossam navigabilem trans Isthmum struendam susceptæ, quo favente hæc et aliæ Filices collectæ sunt nobisque transmissæ. (Ad terram prope cataractum *Truando* Novæ Granadæ, Schott, *n.* 8.)

Genus XXIX. DICKSONIA, *L'Herit.*

1. D. rubiginosa, *Kaulf. Enum. p.* 226; *Hook. Sp. Fil.* 1, *p.* 79, *t.* 27. (Fendl. 58.)

2. D. cicutaria, *Swartz, Syn.* 137; *Hook. Sp. Fil.* 1, *p.* 76. (Fendl. 374. Wright, 895, 962.) (Ex Mettenio no. 962 ad " D. adiantoidem, *Swartz*, certe *Kunze*," pertinet; no. 895 partim ad D. dissectam, *Swartz*, partim ad D. adiantoidem.)

3. D. apiifolia, *Swartz, Syn. p.* 137; *Hook. l. c.* 2, *p.* 77, *t.* 26. (Fendl. 448.)

4. D. CONSANGUINEA, *Klotzsch in Lin.* 20, *p.* 445. D. adiantoides, *Hook. l. c. p.* 75, *t.* 26. (Fendl. 60.)

5. D. ADIANTOIDES, *H.B.K. Nov. Gen.* 1, *p.* 24. (Fendl. 59.)

6. D. LINDENI, *Hook. l. c. p.* 72, *t.* 25. (Fendl. 61.)

7. D. PLUMIERI, *Hook. l. c. p.* 72. (Wright, 897.)

II. CYATHEACEÆ.

Genus XXX. BALANTIUM, *Kaulf.*

1. B. KARSTENIANUM, *Klotzsch in Lin.* 20, *p.* 444. (Fendl. 57.)

Genus XXXI. ALSOPHILA, *R. Br.*

1. A. ASPERA, *R. Br. Prodr. p.* 158; *Hook. & Grev. Ic. Fil. t.* 213, 214, 215. A. hirta, *Kaulf.* var. *Metten.* (Wright, 1062.)

2. A. INFESTA, *Kunze in Lin.* 9, *p.* 98. (Fendl. 56.)

3. A. ATROVIRENS, *Presl. Tent. p.* 61. A. compta, *Mart. Ic. Crypt. Bras. p.* 66, *t.* 41. (Fendl. 383.)

4. A. LEUCOLEPIS, *Mart. l. c. p.* 70, *t.* 46. (Fendl. 53.)

5. A. PUNGENS, *Kaulf.; Moore, Index, p.* 56. (Fendl. 491.)

6. A. ACULEATA, *J. Smith in Lond. Jour. Bot.* 1, *p.* 667. A. armata, *Mart. l. c. p.* 72, *t.* 28, 48. (Hayes, 2.)

7. A. ARMATA, *Presl. Tent. p.* 62. A. Swartziana, *Mart. l. c. p.* 73, *t.* 49. (Fendl. 49.)

8. A. VILLOSA, "*Desv. Prodr. p.* 319" ex *Moore Index, p.* 58. (Fendl. 47.)

9. A. HUMBOLDTII, *Klotzsch; Metten. Fil. Lips. p.* 109. (Fendl. 492.)

10. A. PRUINATA, *Kaulf.; Hook. Sp. Fil.* 1, *p.* 47. (Fendl. 48, 487.)

(Hujus generis sunt, Wright, 951, 1061, 889; Fendl. 55, 344.)

Genus XXXII. HEMITELIA, *R. Br.*

1. H. SPECIOSA, *Kaulf. Enum. Fil. p.* 252; *Hook. Sp. Fil.* 1, *p.* 28, *t.* 13, *& Fil. Exot. t.* 66. H. integrifolia, *Klotzsch in Lin.* 18, *p.* 539; *Metten. l. c. p.* 110. (Fendl. 46.)

2. H. KARSTENIANA, *Klotzsch in Bot. Zeit.* 12, *p.* 439. *Metten. Fil. Lips. p.* 111. (Fendl. 386.)

3. H. OBTUSA, *Kaulf. Enum. p.* 252; *Hook. Sp. Fil.* 1, *p.* 29, *t.* 14. (Fendl. 480.)

4. H. HORRIDA, *R. Br.; Hook. Fil. Exot. t.* 69. (Fendl. 385. Wright, 888.)

(Hujus generis, § Amphicosmia, Wright, 950.)

Genus XXXIII. CYATHEA, *Smith.*

1. C. ARBOREA, *Smith ; Hook. Sp. Fil.* 1, *p.* 17. (Wright, 892, 893, 948.)

2. C. SERRA, *Willd. Sp. Pl.* 5, *p.* 491 ; *Hook. l. c. p.* 17, *t.* 9. (Wright, 891.)

3. C. SCHANSCHIN, *Mart. Ic. Crypt. Bras. p.* 77, *t.* 54. (Fendl. 52.)

4. C. INSIGNIS (sp. nov.): caudice arboreo; stipite badio inermi minute ruguloso paleis cinnamomeis anguste linearibus spinuloso-ciliatis (poll. ad semilineam gradatis) dense vestito; fronde ampla bipinnata basi subtripinnata supra viridi ad costas pubescente subtus pallescente paleis cinnamomeis minutis laciniatis adspersa; pinnis oblongo-lanceolatis brevi-stipitatis; pinnulis utrinque 40 – 50 lanceolatis acuminatis fere ad costam pinnatifidis, vel basalibus iterum pinnatis; segmentis oblongis falcatis obtusis integris vel inferioribus crenato-incisis; soris 8 – 14 in quodam segmento, involucris ochroleucis ovato-spheroideis apice mamillatis demum in laciniis irregularibus dirumpentibus. — Frondes pluripedales. Pinnæ sesquipedales. Pinnulæ crebræ, 3 – 4-poll. longæ. Rachis cum ramificationibus minute rugulosa, paleolis ciliato-laceris conspersa. Involucra sordide alba, subpergamentacea, primum ovoidea, apice macula discolori elevata notata, ætate in laciniis persistentibus divisa. (Wright, 1064.)

5. C. MINOR (sp. nov.): caudice erecto brevi; stipite brevissimo inermi; rachi costisque tenuiter pubescentibus; fronde lanceolata a medio inferne attenuata apice breviter acuminata pinnata; pinnis utrinque 30 – 35 alternis oblongo-lanceolatis ad costam pinnatifidis; segmentis oblongis obtusis, supra glabris, subtus pubescentibus, basali inferiore majore rachi incumbente; soris in quodam segmento 8 – 14; involucris ætate depresso-cyathiformibus margine integris. — Frondes tri – quadripedales, supra medium 8 – 16 poll. latæ, dehinc ad basin attenuatæ. Pinnæ subremotæ patentes, e basi latiore late lanceolatæ, apice crenatæ. Segmenta pinnarum majorum 50 – 70, obliqua, integra, infra ad costulam paleolas paucas bullatas ferentia. Venulæ furcatæ. Sori costulæ approximati. Ab omnibus Cyatheis veris mihi cognitis frondibus minoribus simplicioribusque distincta. (Wright, 949.)

6. C. BALANOCARPA (sp. nov.): caudice arboreo; stipite sparse aculeato basi paleis angustis fuscis obsesso; fronde ampla lanceolata bipinnata utrinque ad costas venulasque, paleis minutis ferrugineis ciliato-laceris pilisque articulatis pulverulenta; pinnis brevi-petiolatis e basi lata lanceolatis acuminatis; majoribus iterum pinnatis, pinnulis utrinque 40 – 50 lineari-oblongis basi inferiore auriculatis dentato-serratis obtusis, dentibus venulam pinnatam excipientibus in axilla ramuli primi soriferis; pinnis minoribus pinnatifidis, laciniis falcatis oblongis obtusis integris vel subdentatis, venulis furcatis in furca soriferis; involucro cyathiformi margine integro, sporangiis ad receptaculum cylindricum

conglobatis ex ore cyathi protrudentibus. — Caudex 10 – 15-pedalis. Stipes digitum crassus, fusco-nigrescens, aculeis nigris sparsis brevibus munitus. Frondes circiter octopedales. Pinnæ maximæ 15 poll. longæ, 3 poll. latæ, in rachim valde approximatæ. Pinnulæ maximæ 18 – 20 lineas longæ, 3 lineas latæ basi inferiore auriculatæ, lineari-oblongæ, dentatæ vel supra medium subintegerrimæ, apice obtusæ, soros 20 – 30 singulos in dentibus singulis ferentes. Pinnulæ minores sive laciniæ semipollicares, soros 6 – 8 versus basin ferentes. Receptaculum sporangiis onustum e cyatho valde protusum tanquam glans e cupula. (Wright, 1063.)

III. HYMENOPHYLLACEÆ.

Generis 34. Trichomanis, *L.*, et 35. Hymenophylli, *Smith*, species nondum elaboratæ.

IV. GLEICHENIACEÆ.

Genus XXXVI. GLEICHENIA, *R. Br.*

1. G. Bancroftii, *Hook. Sp. Fil.* 1, *p.* 5, *t.* 4. (Fendl. 45.)
2. G. pubescens, *Hook. Sp. Fil. p.* 8. (Fendl. 42. Wright, 921.)
3. G. pectinata, *Presl.* G. glaucescens, *Hook. l. c. p.* 11. (Fendl. 482, 483.)
4. G. dichotoma, *Hook. l. c. p.* 12. (Fendl. 44. Wright, 922.)

V. SCHIZÆACEÆ.

Genus XXXVII. SCHIZÆA, *Smith.*

1. S. dichotoma, *Swartz, Syn. p.* 150; *Hook. & Grev. Ic. Fil. t.* 17. (Fendl. 485. Wright, 926.)
2. S. Flabellum, *Mart. Ic. Crypt. Bras. p.* 115, *t.* 55, 56. (Fendl. 396.)

Genus XXXVIII. ANEIMIA, *Swartz.*

1. A. humilis, *Swartz, Syn. p.* 156. (Fendl. 9, 10.)
2. A. incisa, *Schrader; Mart. l. c. p.* 114. (Fendl. 11.)
3. A. Phyllitidis, *Swartz, Syn. p.* 155. A. hirta, *Swartz*, fide *Metten.* (Fendl. 13. Wright, 929, 1067.)
4. A. hirsuta, *Swartz, Syn. p.* 156. (Fendl. 8, 15.)
5. A. flexuosa, *Swartz, Syn. p.* 156; *Hook. Fil. Exot. t.* 30. (Fendl. 6.)
6. A. fulva, *Swartz, Syn. p.* 157; *Hook. Fil. Exot. t.* 26. (Fendl. 7.)
7. A. adiantifolia, *Swartz, Syn. p.* 157. (Wright, 928.)

Genus XXXIX. LYGODIUM, *Swartz.*

1. L. volubile, *Swartz, Syn. p.* 152. (Wright, 925. Hayes, 6.)

2. L. digitatum (sp. nov.): stipite scandente stramineo glabro; pinnis conjugatis petiolo articulatis glabris, 5–7-palmato-partitis; lobis elongato-lanceolatis argute serrulatis, fertilibus secundum marginem lobulos 10–14-soriferos ferentibus, costis ex apice petioli radiatis, venulis e costa pinnatis 1–2-dichotomis in dentes callosos incurvos desinentibus. — Pinnæ rigide-membranaceæ, glabræ, utrinque læte-virides. Incisuræ vix intra semipollicem ad apicem petioli extendentes. Laciniæ 6–9 poll. longæ, 10–12 lineas latæ, pinnulis Lygodii volubilis haud dissimiles. (Ad Gatun, in via ferrea Panamensi, Hayes, 25. Prope cataractum *Truando*, Novæ Granadæ, Schott, 77.)

3. L. Wrightii (sp. nov. a cl. Mettenio edenda). (Wright, 925.)

4. L. venustum, *Swartz; Presl. Suppl. p.* 105. (Fendl. 14. Hayes, 5.)

VI. OSMUNDACEÆ.

Genus XL. OSMUNDA, *L.*

1. O. regalis, *L.*, var. spectabilis. O. spectabilis, *Willd. Sp. Pl.* 5, *p.* 98. O. palustris, *Schrader; J. W. Sturm, in Mart. Flor. Bras. fasc.* 23, *p.* 166, *t.* 12. (Fendl. 5.)

VII. MARATTIACEÆ.

Genus XLI. MARATTIA, *Smith.*

1. M. alata, *Smith; Schkuhr. Fil. p.* 153, *t.* 152. Discostegia alata, *Presl. Suppl. p.* 12. (Wright, 1065.)

2. M. Kaulfussii, *J. Smith in Hook. Gen. t.* 26; *Metten. Fil. Lips. p.* 118. Eupodium Kaulfussii, *J. Smith in Hook. Gen. t.* 118. (Fendl. 3.)

Genus XLII. DANÆA, *Smith.*

1. D. Moritziana, *Presl. Suppl. p.* 35. (Fendl. 1. Wright, 1066.)

2. D. elliptica, *Smith; Hook. & Grev. Ic. Fil. t.* 52. (Fendl. 460. Wright, 924, pro parte.)

3. D. nodosa, *Smith; Hook. & Grev. Ic. Fil. t.* 51. (Wright, 924, pro parte.) (Fragmenta frondium modo visa difficile est inter species tam affines dijudicare, sed duas Filices eodum sub numero distributas esse credo.)

VIII. OPHIOGLOSSEÆ.

Genus XLIII. BOTRYCHIUM, *Swartz.*

1. B. DECOMPOSITUM, *Mart. & Gal. Fil. Mex. p.* 15, *t.* 1. Vix a B. lunarioide diversa. (Fendl. 4.)

Genus XLV. OPHIOGLOSSUM, *Tournef.*

1. O. VULGATUM, *L.*, var. CROTALOPHOROIDES. O. crotalophoroides, *Walt. Fl. Car.* 256. O. bulbosum, *Michx. Fl. Bor. Am.* 2, *p.* 276. (Fendl. 342.)

Var. RETICULATUM. O. reticulatum, *L.* (Fendl. 312. Wright, 930.)

2. O. PALMATUM, *Plumier, Fil. Am. p.* 139, *t.* 163. Cheiroglossa palmata, *Presl, Suppl. p.* 57. Filix insignis, rarissima, sed in remotissimis terræ regionibus reperta. (Wright, 946.)

ERRATA.

Page 193, l. 13, pro "*t.* 6" lege "*t.* 7."
" 194, n. 21, pro "*p.* 49" lege "*p.* 3, *t.* 15."
" 196, l. 22, lege CH. AUREUM, *Fée;*
" " l. 24, " ANAPAUSIA.
" 197, l. 28, " *Metten. Fil. Lips. p.* 32.
" 198, n. 17, " *p.* 12, *t.* 8.
" " n. 18, " *p.* 12, *t.* 10.
" " n. 24, " *p.* 126.
" 199, n. 32, " *p.* 393.
" " n. 34, " Fendl. 243?
" " n. 46, " *n. ser.* 27.
" 200, n. 48, adde (Hujus affine Fendl. 247.)
" " n. 50, lege *Jour. Bot.* 6.
" " n. 50, " Gatun.
" " n. 57, " Fendl. 223.

APPENDIX.

Orchideæ Wrightianæ et Fendlerianæ, ex cl. LINDLEY.

Orchideæ Wrightianæ Cubenses.

No. 613. Microstylis umbellulata.
614. Microstylis spicata.
615. Pogonia macrophylla.
616. Pleurothallis oblongifolia.
617. Pelexia setacea.
618. Stenorhynchus orchioides.
619. Spiranthes elata.
620. Cranichis muscosa.
621. Cranichis monophylla.
622. Sauroglossum tenue, n. sp.
623. Physurus plantagineus.
624. Physurus hirtellus.
625. Habenaria maculosa.
626. Prescottia colorans.
627. Polystachya luteola.
628. Epidendrum fuscatum.
629. Pleurothallis prostrata, n. sp.
630. Epidendrum ramosum.
631. Govenia lagenophora.
632. Maxillaria pallidiflora.
633. Isochilus lineare.
634. Lycaste ciliata.
635. Epidendrum variegatum.
636. Epidendrum fragrans.
637. Cœlia Baueriana.
638. Maxillaria crassifolia.
639. Brassia caudata.
640. Epidendrum cochleatum.
641. Bletia verecunda.
643. Epidendrum polygonatum, n. sp.
644. Epidendrum rivulare, n. sp.
645, 646. Epidendrum umbellatum.
647. Dichæa, n. sp.
648. Pleurothallis testæfolia, n. sp.
649. Dinema polybolbon.
650. Camaridium vestitum.
651. Pleurothallis Grobyi et P. longilabris, n. sp.
652. Masdevallia fenestrata.
653. Pleurothallis Cubensis.
654. Octomeria tridentata.
655. Pleurothallis albida, n. sp.
656. Pleurothallis univaginata, n. sp.
657. Pleurothallis rubigena, n. sp.
658. Stelis ophioglossoides.
659. Pleurothallis trichophora, n. sp.
660. Pleurothallis Wilsoni.
661. Lepanthes trichodactyla, n. sp.
662. Lepanthes dorsalis, n. sp.
663. Pleurothallis fallax.
664. Comparettia falcata.
665. Broughtonia sanguinea.
666. Oncidium luridum.
667. Ionopsis Gardneri.
668. Oncidium variegatum.
669. Oncidium usneoides, n. sp.
670. Oncidium sylvestre, n. sp.
671. Bletia patula.
672. Vanilla claviculata.
1471. Chloidia vernalis.
1472. Physurus hirtellus?
1473. Prescottia pellucida.
1474–1476. Ponthieva glandulosa.
[1477, 1478 = 1479?]
1479. Cranichis pauciflora.
1480. Cranichis monophylla.
1481. Habenaria, n. sp.
1482. Spiranthes Gardneri.
1483. Cœlia Baueriana.
1484. Maxillaria alba.
1485. Maxillaria rufescens.
1486. Dichæa echinocarpa?
1487. Dichæa, n. sp. = 647.
1488. Oncidium sylvestre, n. sp.
1489. Epidendrum replicatum.
1490. Epidendrum discolor; E. nocturnum, var.
1491. Epidendrum rigidum.
1492. Epidendrum phœniceum.
1493. Evelyna graminifolia.
1494. Isochilus globosum.
1495. Liparis.
1496. Pleurothallis testæfolia, n. sp.
1497. Angræcum Pœppigii.
1498. Epidendrum umbellatum, var.
1499. Pleurothallis velaticaulis.
1500. Pleurothallis prostrata.
1501. Pleurothallis hymenantha.
1502. Pleurothallis longilabris, n. sp.
1503. Pleurothallis Grobyi.
1504. Pleurothallis mucronata, n. sp.
1505. Pleurothallis "trigonifolia et tuberculata, Wright."
1506. Pleurothallis, n. sp.?
1507. Pleurothallis, n. sp.?
1508. Lepanthes ciliata.
1509. Pleurothallis floripicta.
1510, 1511. Lepanthes tridentata, Sw., non Lindl. Bot. Reg.
1512. Lepanthes Pristidis.
1513. Pleurothallis, n. sp.
1690. Epidendrum umbellatum.

1691. Microstylis spicata.
1692. Angræcum, n. sp.
1693. Epidendrum Wrightii, n. sp.
1694. Habenaria.
1695. Warcziewiczella discolor.
1696. Microstylis umbellulata.
1698. Galeandra Beyrichii?
1699. Epidendrum auritum.
1700. Dichæa glauca.
1701. Dichæa squarrosa.
1702. Dichæa muricata.
1703. Ponthieva glandulosa?
1704. Pleurothallis obovata.
1705. Pleurothallis ruscifolia.
1706. Pleurothallis velaticaulis.
1707. Lepanthes trichodactyla, n. sp
1708. Lepanthes fulva.
1709. Pleurothallis, n. sp.?

Orchideæ Fendlerianæ Venezuelanæ.

1361. Masdevallia Tovariensis?
1362. Masdevallia maculata?
1363. Masdevallia aff. meleagri.
1364. Comparettia falcata?
1365. Scelochilus.
1366. Warcziewiczella discolor.
1367. Ornithocephalus.
1369–1373. Masdevalliæ, spp.
1375. Warcziewiczella, n. sp.
1376. Oncidium æmulum.
1377. Acineta Humboldtii.
1378. Oncidium zebrinum.
1379. Oncidium, n. sp.
1380. Oncidium luridum?
1382. Odontoglossum.
1383. Epidendrum ciliare.
1384. Epidendrum cuspidatum.
1385. Stanhopea.
1388. Leochilus, n. sp.
1389. Trizeuxis falcata.
1390. Ornithocephalus.
1393. Maxillaria rufescens.
1394. Bolbophyllum bracteolatum.
1395. Govenia.
1396. Källensteinia.
1397. Chloidia.
1399. Bletia.
1400. Bletia.
1405. Stenorhynchus.
1406. Physurus.
1407. Spiranthes aff. Galeottianæ.
1408. Habenaria aff. gracili.
1409. Habenaria spathacea.
1410. Malaxis (Liparis) Galeottiana.
1411. Ponthieva glandulosa.
1412. Cranichis.
1420. Physurus.
1421. Epidendrum aff. patenti et macrobotryo.
1422. Liparis.
1423. Physurus.
1425. Microstylis.
1429. Telipogon.
1430. Epidendrum umbellatum.
1434. Habenaria Lindenii.
1435. Epidendrum.
1437. Habenaria brachyceras.
1438. Habenaria entomantha.
1439. Habenaria maculosa.
1440. Epidendrum.
1441. Ornithidium.
1442. Epidendrum rigidum.
1445. Epidendrum, n. sp.
1447. Epidendrum brachychilum.
1448. Epidendrum parallelum?
1452. Epidendrum orchioides.
1453. Epidendrum Lindenii.
1454. Camaridium?
1455. Ornithidium miniatum.
1456. Ponera striata.
1457. Dichæa muricata.
1458. Angræcum aff. Organensi.
1460. Stelis muscifera, n. sp.
1461. Stelis lutea, n. sp.
1464. Stelis sphærochila, n. sp.
1465. Stelis cymbiformis, n. sp.
1466, 1467. Stelis humulis, n. sp.
1468. Stelis muscosa, n. sp.
1469, 1471. Stelis tenuilabris, n. sp.
1470. Stelis Fendleri, n. sp.
1476. Pleurothallis lanceolata.
1485. Restrepia Lansbergii & var. Wageneri.
1770. Epidendrum nutans.
2124. Epidendrum macrochilum.
2127. Dicrypta discolor?
2129. Didactyle, n. sp.
2135. Cranichis.
2136. Cranichis.
2137. Spiranthes elata.
2138. Epidendrum, n. sp.
2139. Physurus.
2140. Prescottia aff. micranthæ.
2141. Liparis aff. vaginatæ et bituberculatæ.
2142. Epidendrum nocturnum.
2144. Stelis coriifolia, n. sp.
2145. Ornithidium sanguinolentum.
2146. Ornithidium (Sophronitis).
2147. Dichæa.
2151. Masdevallia.
2154. Stelis alata, n. sp.
2132. Scaphyglottis violacea.
2435. Comparettia coccinea.
2436. Epidendrum marbicornutum.
2438. Spiranthes grandiflora.
2440. Maxillaria Meridensis.
2583. Gongora Jenischii.
2621. Warcziewiczella.
2622. Pleurothallis tripterantha.
2624. Pelexia.

VIII.

On the Light of the Moon and of the Planet Jupiter.

By GEORGE P. BOND.

(*Communicated September* 11, 1860.)

On the 22d of March, 1851, several daguerrotype pictures of Jupiter were obtained on plates exposed at the focus of the great refractor of the Observatory of Harvard College. The belts were faintly indicated; but the most interesting fact in connection with the experiment, apart from its having been, as is believed, the first instance of a photographic impression obtained from a planet, was the shortness of the time of exposure, which was nearly the same as for the Moon, whereas, considering the relative distance of the two bodies from the Sun, it was to have been expected that the light of the Moon would have had twenty-seven times more intensity than that of Jupiter, supposing equal capacities for reflection. The experiments were repeated on the 8th and 9th of October, 1857, by Mr. Whipple, using the collodion process, with a like result.

The energetic action of the light of Jupiter was noticed by De La Rue, in December, 1857. The following is an account of his experiments.

"Recent experience in photographing the Moon and Jupiter having given me the impression that the light of that planet, in proportion to its luminosity, possessed considerably more actinic power than that of the Moon, I determined on testing the correctness of this view, experimentally, on the first favorable opportunity. On December 7th, the Moon and Jupiter being, during a part of the night, at nearly the same altitude, although in different parts of the heavens, I turned the telescope alternately on one and the other body, and thus obtained several photographs (six of each), under almost identical conditions. Generally nine to ten seconds were sufficient for the Moon pictures, and twelve seconds for those of Jupiter; hence, although the light of the Moon is at least twice as bright as that of Jupiter, its actinic power would

appear to be not greater than as from 6 to 5 or 6 to 4. It is not improbable that the blue tint of Jupiter may have something to do with its photogenic power. It may be also stated, that the darkest parts of Jupiter's surface came fully out by an exposure which did not suffice to bring out those portions of the Moon situated near the dark limb, and consequently illuminated by a very oblique ray; thus confirming an observation already communicated by me."

"As the night advanced, I was able to take pictures of Jupiter in five seconds, in consequence of the planet attaining a greater altitude; and the position of Saturn being favorable for a comparison of its actinic power with that of Jupiter, I turned the telescope alternately on each of these two planets, and found that, to produce pictures of equal intensity, the sensitized plate had, on the average, to be exposed 5 seconds to Jupiter, and 60 seconds to Saturn. Hence the chemical rays from Jupiter are twelve times more energetic than those from Saturn, — an effect undoubtedly in a great measure attributable to the greater brilliancy of the former planet, but not, I believe, entirely so." *

Further comparisons between the Moon and Jupiter, made at the Observatory of Harvard College in 1860, have suggested a variety of experiments, relating to their optical as well as to their photographic intensities, which will be described in the following pages. A short explanation of the methods used in the reduction of the observations, and a general summary of the conclusions to which they have led, will first be given.

The latter must be received with proper allowance for the difficulties incident to all photometric experiments, and perhaps not less so to their subsequent interpretation. We have no means of measuring degrees of optical intensity, other than by the precarious standard afforded in the sensation produced upon the eye, and since this involves much that is merely subjective and liable to alter with each new observer, or even with the same individual at different times, the data must be exposed to considerable uncertainty from this source alone. The photographs, it is true, are not affected in the same way, yet they have their peculiar failing in the irregular action of the chemicals. Again, the variable clearness of the sky, and differences of color and quality of light, have an influence both upon the photographic and optical rays, which it is impossible to eliminate completely. For these reasons, it is desirable to

* Monthly Notices Royal Astr. Soc., Vol. XVIII. p. 55. The instrument was a Newtonian reflector of 13 inches' aperture. De la Rue photographed Saturn side by side with the Moon, May 8th, 1859, and obtained a distinct, though somewhat faint picture, in 15^s. The intensity of sunlight at this planet is only about $\frac{1}{90}$ of that at the Moon.

multiply the number of individual determinations, and to vary the methods of observation, so as to approach the subject from as many different quarters as possible. Even when this has been done, it is not always that we can be secure of assuming correct principles on which to proceed in deducing from the data their legitimate consequences.

The times of exposure required to produce daguerrotypes, or strong "negative" photographs, of the Moon and Jupiter, have been derived from observations made upon twenty-one nights from 1851 to 1860 inclusive.

On classifying those for the Moon according to its angle of elongation from the Sun, it appears that there is a continuous decrease in the duration of exposure from new to full moon. At the latter phase, when the elongation is 180°, only *one sixth* as much time is required as at the phase for which the elongation is 60°, the Moon then being four or five days old.

The question, it must be remembered, is one of intensity, not quantity of light. In the latter the disproportion is very much greater, because the difference in the extent of illuminated area is also to be considered. The above results have suggested an examination of the proportions between the illuminating power of moonlight at the several phases, which are considered in another connection.

By comparing the exposures for the Moon with those for Jupiter, the photographic intensity of the latter is found to be *nine* times that of the average surface of the full Moon, including the whole visible hemispheres of both bodies, and *twenty-seven* times greater if we have regard only to the central regions of the Moon and the bright belts of the planet. From a subsequent discussion of all the data, it was concluded that Jupiter reflects out of a given quantity of incident light, *fourteen* times more of the chemical rays than the Moon does. In other words, that the latter, if the constitution of its surface resembled that of Jupiter, would photograph in *one fourteenth* of the time which it actually requires; but if we have regard only to the brightest regions of the planet, the disparity in times of exposure must be increased to the ratio of perhaps 1 to 30, or even more.

It is shown that there is not sufficient difference in the color of the two objects, to account for this inequality in photographic power. This is proved by comparisons with artificial light of different tints, reflected from silvered glass globes side by side with the images of the Moon and Jupiter, and by other evidence. The artificial illumination from the "Bengola" or "blue-light" nearly resembled moonlight in color.

The distribution of light over the discs of Jupiter and the Moon presented, in the photographs, a decided contrast; the former is brightest near the centre in zones parallel to the equator, the latter near the margin.

The proportions between the intensity of the chemical rays from the Sun and those from the Moon and Jupiter, were next ascertained. For the Sun and Moon the proportion found was the ratio 340,000 to 1. Comparisons were also made between the Moon and the Earth's landscape, indicating that the latter has a somewhat feebler photographic power than the Moon.

No satisfactory explanation of the superior chemical energy of the light of Jupiter having presented itself, attention was next directed to the relative intensity of the visual rays from the same objects.

In the account of these experiments an exposition is first given of the photometric formulæ required in the discussion of the observations, with particular reference to the relative brightness of the Sun, and of the Moon or planets illuminated by it, as seen from the Earth. Different writers have arrived at very discordant representations of the ratio of the quantity of light afforded by the full Moon compared with sunlight, supposing none to be lost in reflection from its surface. Attention has been given to the cause of the discrepancies, and to the effect of changes in the phase of the Moon or planet in modifying both the amount of light transmitted to the Earth, and its distribution over the illuminated area.

The changes of moonlight at the several phases, computed from Lambert's and Euler's theories, compared with Herschel's series of photometric determinations made in 1836 at the Cape of Good Hope, were found to bear scarcely any resemblance to the observed values. This discordance was confirmed by a new series of experiments, agreeing closely in their indications with those of Herschel. The fact that the two series were originally destined for quite different purposes, adds to the force of this confirmation. Of the two theories, Lambert's deviates the least from the truth, still, however, making the half-moon from two to three times too bright; and since it is based upon a principle found experimentally to be generally true for opaque substances, it would seem that the constitution of the Moon's surface in respect to its reflective properties is peculiar. The brightness somewhat suddenly increasing when it approaches opposition, as though the greater number of the reflecting facets of its asperities were disposed at right angles to the radius vector of the orbit, causing a sudden glance of light analogous to that which we may see in micaceous rocks.

It deserves notice that such a tendency would also accord with the actual distribution of light at full moon; for, in this case, the brightness ought to increase towards the margin of the disc, as it actually does, whereas Lambert's theory requires that it should decrease.

Jupiter, on the other hand, agrees sufficiently well with Lambert's theory, as

respects the distribution of light over its disc. Mars, when near its full phase, has a nearer resemblance to the Moon.

In the course of the observations upon the quantity of moonlight received from the different phases, comparisons were also made, by the same method, upon Jupiter and Venus, furnishing the following results:—

$$\frac{\text{Brightness of Jupiter at mean opposition}}{\text{Brightness of mean full Moon}} = \frac{1}{6430}$$

$$\frac{\text{Brightness of Jupiter at mean opposition}}{\text{Brightness of Venus at greatest brilliancy}} = \frac{1000}{4864}$$

The subject next discussed has been the albedo, or reflective capacity, of the Moon and Jupiter. That of the Moon is represented by the expression

$$\mu = \frac{45193}{S},$$

S being the ratio of sunlight to full moonlight at the earth. If we assume the mean between Bouguer's and Wollaston's determinations, we have very nearly,—

$$S = 550000.$$

A new determination of this proportion, communicated in a subsequent memoir, has given the value

$$S = 477530.$$

It appears, therefore, that the Moon absorbs about ten parts out of every eleven of the light incident upon it; that is, we have

$$\mu = \frac{1}{11}.$$

The albedo of Jupiter compared with the Moon was found to be

$$\frac{\mu''}{\mu} = 11.47.$$

Hence we arrive at the singular conclusion, that the albedo of Jupiter is

$$\mu'' = \frac{11.47}{11} = 1.04,$$

much exceeding that of the whitest opaque substance known. Its optical brilliancy presents therefore an anomaly similar to that recognized in the chemical rays, for we have for the latter,—

$$\frac{\text{Chemical albedo of Moon}}{\text{Chemical albedo of Jupiter}} = \frac{1}{14}$$

Strictly speaking, a value of μ'' exceeding unity would indicate that Jupiter shines partly at least by native light. We must remember, however, in interpreting these results, that neither the observations nor the theoretical conditions assumed in discussing them are entitled to implicit confidence.

Experiments made upon the reflective capacity of various substances on the Earth's surface lead to the conclusion that the optical albedo of dark, weather-worn rocks, dry earth, sand and gravel, and of the Earth's landscape generally, approaches that of the Moon, so that in reflective power there is no considerable difference between the two bodies. No substance was found of a whiteness comparable to that of the bright belts of Jupiter, still less to that of the brilliant spots which at times appear on its surface.

The distribution of light over the disc of the planet has been ascertained by means of transits of the satellites, which present very curious phenomena, only to be explained by supposing a disproportion greater than 6 to 1 between the brightness of the central regions and the margin of the planet. The observations which have been made in reference to this question are sufficiently well explained by this supposition, though it is difficult for the eye, at first sight, to recognize the disparity. The fact is of some importance in the determination of the albedo of the planet, since it accords sufficiently well with Lambert's theory, and indicates that the application of the latter to Jupiter has not tended to an over-estimate of its reflective power.

We will now proceed to a more detailed account of the experiments and process of reduction upon which the above conclusions have been founded.

The following numbers, although obtained from trials made for quite a different purpose, and affected to some extent by the unstable condition of the chemicals, the degree of clearness of the sky, &c., will serve to give a tolerably correct idea of the excess of chemical intensity of the light of Jupiter contrasted with moonlight, after due allowance for the respective distances of the two bodies from the Sun.

The plates compared were taken by Mr. Whipple, or by his partner in business, Mr. Black, on the following dates; v representing the angles of elongation of the Moon from the Sun.

1851, March 12,	Moon,	$v = 117^\circ$	Exposure	10^s to 15^s	Daguerrotype.
" " 22,	Jupiter,	$v = 175$	"	About as long as for the Moon, or a little longer.	"
1852, Feb. 26,	Moon,	$v = 76$	"	15^s	"
" March 3,*	"	$v = 151$	"	6^s to 8^s	"

* In a memorandum dated March 3, 1852, it is stated, as the result of other trials not recorded in detail, that the full Moon required 5^s or 6^s to daguerrotype its image.

1852, April	24,	Moon,	$v = 62^\circ$	Exposure	20^s	Daguerrotype.
1857, April	4,	"	$v = 131$	"	13	Collodion.
" "	27,	"	$v = 52$	"	80	"
" "	28,	"	$v = 65$	"	60	"
" "	30,	"	$v = 90$	"	45	"
" May	6,	"	$v = 159$	"	13	"
" "	8,	"	$v = 181$	"	4 Faint action in $< 1^s$.	"
" Oct.	3,	"	$v = 173$	"	4 or 5^s, not well determined.	"
" "	7,*	"	$v = 116$	"	2 or 3 times as long as on 3d.	"
" "	8,*	Jupiter,	$v = 174$	"	Same as for average of Moon's surface.	"
" "	8,	Moon,	$v = 101$	"	33 ?	"
" "	9,*	Jupiter,	$v = 174$	"	20 ?	"
1860, Jan.	30,	Moon,	$v = 87$	"	16	"
" "	30,	Jupiter,	$v = 176$	"	13	"
" Feb.	7,	Moon,	$v = 166$	"	7	"
" April	6,	"	$v = 164$	"	5	"
" "	28,	"	$v = 95$	"	13	"

From the above, and from other trials of which no precise record was preserved, I conclude that, with the chemical preparations used, the times of exposure for strong "negatives" of the Moon at different phases, after applying a correction for extinction at different altitudes,† are as follows:—

$v = 60^\circ$	Exposure	$= 30^s$
$v = 90$	"	$= 20$
$v = 120$	"	$= 15$
$v = 150$	"	$= 10$
$v = 180$	"	$= 5$

It is not easy to decide with certainty respecting these times without experiments made especially for the purpose. When the object in view is solely the production of a good picture, as was the case here, the exposure cannot be continued long enough to give a strong negative of the regions towards the dark limb, near the quadratures, without injury to the image of the bright limb by over-exposure.

For an equally intense picture of the planet, the time of exposure is

$$v = 175^\circ \qquad \text{Exposure} = 15^s.$$

* On examining the object-glass, Oct. 11th, moisture was found deposited between the lenses, which probably affected the experiments on Oct. 7th, 8th, and 9th.

† Assumed to be the same as for the optical rays.

Some parts of Jupiter, as, for instance, on Jan. 30, 1860, a bright region in its northern hemisphere, about 25° in latitude from its equator, afforded traces of chemical action in less than a second; the parts of the full Moon, similarly situated relatively to the Sun and to the Earth, in about the same time. With a similar reflecting surface, the illumination of the two bodies should be in the inverse ratio of the squares of their distances from the Sun, or as

$$1 : 5.203^2 = 1 : 27,$$

instead of which we have, from the above data: —

Phase of Moon at $v = 90°$	Ratio of exposures $30^s : 15^s = 2 : 1$
" " $v = 180$	" " $5 : 15 = 1 : 3$ to $1 : 1$ for bright belts.

The disproportion at the different phases of the Moon will be more fully considered in another place. The two bodies are presented to us under nearly similar circumstances, as respects the angle of the illuminating rays and the line of vision, at about the times of the Moon's opposition, in which position the ratio of their chemical powers, supposing each to be so placed as to receive equal illumination from the Sun, would become, —

Photographic intensity of Jupiter $= \frac{1}{3} \times 27 =$ 9 times that of the average surface of the full Moon,

" " " $= \frac{1}{1} \times 27 = 27$ " " " " " "

according as we compare the whole visible surface of the two spheres, or only the central parts of the Moon presented nearly at right angles to the direction of vision and of illumination, with the brighter belts of the planet which are similarly situated.

There is one circumstance which makes the contrast the more remarkable; it is that a very small image, like that of the planet, photographs to disadvantage compared with a larger one of equal intensity, for want, apparently, of the sympathy induced by the chemical action going on in other parts of the plate. I should anticipate from this circumstance, that, in a comparison with the Moon, we should be likely to underrate the actinic power of Jupiter.

The explanation suggested by Mr. De la Rue in the passage above quoted, attributing the differences in photographic power to a diversity in color, cannot be sustained, since there is no satisfactory evidence of any decided difference between Jupiter and the Moon in point of color, but rather the contrary. A decided blue or green tint in Jupiter is only noticed when it is almost in contact with the limb of the Moon. The retina being then excited by the stronger light of the Moon, the planet perhaps

assumes a bluish cast due to the effect of contrast in intensity and quantity rather than of actual color. Arago,* to account for the supposed bluish tints of the Mare Crisium and Mare Serenitatis on the Moon, suggests that the general tint of the latter is yellowish. That the moonlight has no decided tinge of red appears from casual remarks made by Sir John Herschel in the account of his comparisons of various stars with the image of the Moon formed in the focus of a lens. For instance, to observations made April 27, 1836, the note is added, "The Moon's image is *too yellow* for β Crucis,"† a star elsewhere described as white. And again, "γ Crucis" (a red star) "is too *red* for the Moon."

By comparing images reflected from a silvered glass globe, I have found that the color of moonlight more nearly resembles that of the flame of a "blue-light" or "Bengola" light than that of any other artificial light which was tried, — indeed, no difference could be perceived between the "Bengola" and the Moon in this respect. The whitest part of the flame of the Carcel or French "moderateur" lamps is decidedly red, contrasted with the image of the moon; that of a candle‡ or common oil-lamp appears of a dingy, yellowish red. The Drummond light is of a golden yellow when contrasted with sunlight. I have not recognized, in point of *color*, any considerable difference between the light of the Moon, Jupiter, Venus, and the Sun, when tested by this method.

The following description by Mr. De la Rue, in October, 1856, would make the general hue of Jupiter yellowish rather than blue: —

"The southern belt of Jupiter appeared, on most occasions on which I have observed it, to be somewhat darker than the northern, which has always been more diffuse and more broken up by intervals and streaks; the northern also has invariably been the broader of the two. Both belts are unmistakably brown as compared with the general tint of the planet, which about the poles has a decidedly yellow hue, and more obviously so towards the north. Besides the very conspicuous broad belts, there were observed several delicate and faint streaks extending to a greater or less distance across the disc, but seldom entirely across it; these faint streaks just under the north belt were decidedly yellow."§

* Pop. Astron., Eng. Trans., Vol. II. p. 287. See also the explanation applied by Mr. Grove to the appearance presented by Jupiter. Monthly Notices Royal Astr. Soc., Vol. XVII. p. 13.

† Obs. Cape of Good Hope, p. 360.

‡ See also the remark of Arago. "One of the principal sources of error seems to me to be the difficulty of comparing the white light of the Sun or of the Moon, which then looks bluish, by contrast with the reddish light of a candle." — Popular Astron., Eng. Trans., Vol. II. p. 288.

§ Monthly Notices Astr. Soc., Vol. XVII. p. 5.

Breen, observing an occultation of the planet with the Northumberland Equatorial, in May, 1850, noted very little difference of color between it and the Moon.

At its emersion from the Moon's bright limb, May 23, 1860, I could discern no difference of tint; this, however, was in the daytime, when both objects were comparatively faint. Mädler considers the prevailing tint of Jupiter to be yellowish, that of the belts, brown and lead-color;* while the Moon is in some parts pure white, in others steel-gray, or tinged with green.

Tints of brick-red or of reddish-brown, and others of a bluish cast, slate, or lead-color were sufficiently evident upon Jupiter in 1860. It deserves notice that the shades of coloring were unusually marked in the early part of this year, at a time when the photographic image presented a decided inequality of action in different parts of the disc. On January 30th, 1860, this was apparent in the formation of a zone between the parallels of 20° and 30° of north latitude in an exposure of two or three seconds, another, less strong, showing itself in the southern hemisphere; the intermediate equatorial zone had less intensity, and the margins of the disc were much fainter than the central parts. Secchi† describes the principal belt as decidedly red, with several bands of green and white alternating. Others mention red and blue tints, more particularly the former.

The evidence is quite sufficient to show that the colors of the Moon and Jupiter are too nearly alike to furnish an explanation of their very unequal chemical energies.

The distribution of light over their discs, so far as this is indicated by photography, presents a striking contrast. The full Moon invariably develops first at the margin, and Jupiter as decisively in the centre, in this particular resembling the Sun, although the defect of illumination at the edge of the latter is less in proportion than with Jupiter. The distortion of the figure generally apparent in the photographs of Jupiter can only be ascribed to the unequal intensity of the rays from different parts of the disc.

In a group of images taken October 8th, 1857, the light action is much more uniform than in 1860; the narrow stripe at the equator, noticed also on the next evening, contrasts curiously with the images on January 30th, 1860. In both, the deficiency at the margin is best exhibited in the difference of size of the images at different exposures. With the Sun and Moon the contrast in this particular appears most plainly while the image is developing.

For the purpose of comparing the photographic power of sunlight with that of

* Populäre Astron., p. 226.

† Monthly Notices Astr. Soc., Vol. XX. p. 71.

Jupiter and the Moon, the aperture of the object-glass was reduced, on the 12th of April, 1860, from 14.94 inches, with which the latter were taken, to 0.021 inch. The Sun's image then photographed in six fifths of the time required for the full Moon, the sky being clear and the conditions in other respects being alike for both. From this experiment it would appear that sunlight surpasses that of the Moon in actinic energy in the proportion

$$\frac{5}{6}\left(\frac{14.94}{0.021}\right)^2 \times 0.805 = 340000.$$

The altitude of the Sun was 50° and that of the Moon 28°. The coefficient 0.805 has been applied as a correction for extinction by the atmosphere, assumed to be the same for the photographic as for the visual rays. The aperture used for the Sun was a hole turned in a plate of brass; the edges were clean-cut and free from dust or obstructions, but not polished. It is perhaps possible that the smallness of the aperture employed is an objection to this result.

On the 7th of April, 1860, the sky being clear and the Sun's altitude about 45°, it was found that a collodion plate exposed at the focus of the great refractor received images of equal intensity with the lunar photographs, under the following exposures and apertures.

1. Side of a house painted of a pure white and presented to the Sun's rays at an angle of incidence of 45°; distant 1300 ft. Aperture reduced to 5 inches; time of exposure $\frac{7}{3}$ of that for full Moon's picture of equal intensity.

2. Experiment repeated, and the ratio found to be $\frac{7}{4}$, comparing with the brighter parts of the Moon.

3. Aperture changed to 9 inches. Exposure the same as for the Moon's average surface. Picture too faint.

4. Aperture 9 inches; images of equal strength require $\frac{13}{8}$ longer exposure than for the Moon.

5. The landscape in the azimuth opposite to that of the Sun required three or four times as long an exposure as the Moon, but the sky in the horizon was much brighter than the Earth's surface.

The above experiments are not entirely conclusive, on account of the uncertainty of the action of the chemicals; but there seems to be no doubt that the reflective properties of the Moon's surface for the chemical rays rather exceed than fall short of those of the main features of a landscape view on the earth. The only object which decidedly surpassed the Moon in photographic power was a very white surface, which

I afterwards found to be scarcely distinguishable in brilliancy from the whitest paper. This was from two to three times more energetic in its action on the plate than the Moon. On repeating the experiment July 2, 1860, with the Sun at an altitude of above 65°, and in a clear sky, it was concluded that the same object had about four times the intensity of the light of the full Moon.

The very remarkable photographic power possessed by the rays of Jupiter, which a comparison of these results with others already detailed obliges us to admit, naturally suggests the enquiry, whether the visual rays from this planet present any similar phenomenon. Before considering this subject, however, it will be convenient to explain the method followed in the reduction of the observations.

Let I represent the whole quantity of light emitted, uniformly in all directions, from any luminous point; r, the distance from I of a sphere s.

The light from I being dispersed equally in all directions, every point on the concave surface of a sphere circumscribed about I with a radius r, will be uniformly illuminated. If s seen from I subtends an angle $2h$, the proportion of the light of I which it will intercept will be

(1) $$i = I \sin.^2 \frac{1}{2} h.$$

If ρ is the radius of s, we have when ρ is small

(2) $$\sin. \frac{1}{2} h = \frac{1}{2} \frac{\rho}{r}; \qquad i = \frac{1}{4} \frac{\rho^2}{r^2} I.$$

But if s is not a sphere, we have

(3) $$i = \frac{1}{4} \frac{p}{\pi r^2} I,$$

p being the projection of the surface of s exposed to the light upon the concave; or, when h is small, its projections as seen from I upon a plane perpendicular at s to the line joining I and s.

The quantity reflected back from s in a given direction will be determined by the nature of its surface. A certain proportion, represented by $1 - \mu$ will be absorbed, leaving μi for the whole quantity reflected.

The ratio

(4) $$\mu = \frac{\text{whole amount of light reflected from } s}{\text{whole amount of light incident upon } s}$$

is called the *albedo* of the surface.

Let $d s'$ be an element of surface illuminated by light reflected from s, Δ its distance from s, $d p'$ its projection upon a plane perpendicular to the line joining s and $d s'$, and

Θ the ratio between the actual amount of light reflected from s upon ds' and the quantity which the latter would receive if the light μi were dispersed equally in all directions from s; we shall then have, for the light incident upon ds',

(5) $$di' = \Theta \frac{\mu i}{4\pi} \frac{dp'}{\Delta^2}.$$

The coefficient Θ depends upon the reflective properties of the surface s, as well as on the angle between ds' and I seen from s. Its value in some special cases, we will now consider.

1. A polished sphere, illuminated by parallel rays, reflects them with uniform intensity over the whole surface of the surrounding concave,* and we shall have

(6) $$\Theta = 1, \qquad di' = \frac{\mu i}{4\pi} \frac{dp'}{\Delta^2}.$$

2. If s is a flat, opaque disc, it will return back the light incident from I into the same hemisphere in which I is situated, and if this be done in equal amounts in every direction towards which its bright side is presented, then

(7) $$\Theta = 2, \qquad di' = \frac{\mu i}{2\pi} \frac{dp'}{\Delta^2}.$$

3. If, at equal distances, the quantity of light reflected from this disc upon ds' is proportional to its apparent area seen from ds', we have

(8) $$\Theta = 4 \sin. \phi, \qquad di' = \frac{\mu i}{\pi} \frac{dp'}{\Delta^2} \sin. \phi.$$

where ϕ is the angle which the line joining s and ds' makes with the plane of the disc.

The reason for adopting this value of Θ is not quite as clear as in the previous cases. It is evident, however, that the apparent area of the disc represented by s, seen from ds', varies as $\sin. \phi$, and that di' will vary also with $\sin. \phi$. Moreover, the sum of all the values of di' must be equal to the whole of the light reflected from s, so that we ought to have

(9) $$\int di' = \mu i,$$

the integral being taken so as to include all positions of ds'.

* Bouguer, Traité d'Optique, p. 109.

If we extend the integral of $\sin.\phi\, dp'$ over the whole surface of the hemisphere upon which s shines, taking Δ for the radius, it becomes

$$\int \sin.\phi\, dp' = \pi \Delta^2,$$

which gives from (8)

$$\int di' = \frac{\mu i}{\pi \Delta^2} \int \sin.\phi\, dp' = \mu i,$$

as in (9).

The case of most astronomical interest is that of a sphere illuminated by parallel rays. Since the diameters of the heavenly bodies are small compared with their distances from each other, we may, without sensible error, obtain the amount of sunlight incident upon a planet from the formula given above, viz.: —

$$(10) \qquad i = \frac{1}{4} \frac{\rho^2}{r^2} I,$$

where I is the whole light emitted by the Sun, ρ the semi-diameter of the planet, and r its distance from the Sun.

If we take de for an element of surface at the Earth presented perpendicularly to its radius vector, R, we obtain from (3) for the amount of sunlight incident upon de,

$$(11) \qquad dL = \frac{I}{4\pi} \frac{de}{R^2}.$$

To find the proportion of sunlight reflected back from a planet upon the Earth compared with that which the latter receives directly from the Sun, we may substitute in (5) the value of i obtained from (10); this will give for the light of the planet incident upon de, if the latter is presented perpendicularly to the line Δ joining the Earth and planet,

$$(12) \qquad di' = \frac{\Theta \mu I \rho^2 de}{16\pi\, r^2\, \Delta^2}.$$

Hence,

$$(13) \qquad \frac{di'}{dL} = \frac{\Theta \mu}{4} \frac{R^2 \rho^2}{\Delta^2 r^2}$$

will represent the ratio of the light reflected from the planet upon the earth, to that which the latter receives from the Sun.

The attempts which have been made to compute the proportion between full moonlight and sunlight upon theoretical principles, supposing none to be absorbed by the Moon, present singular discrepancies. Thus we have, according to different authorities,

(*a*)	$\frac{\text{Full Moonlight}}{\text{Sunlight}}$	$= \frac{1}{450000}$	Mitchell as quoted by Wollaston, Ph. Tr., 1829, p. 20. Probably a misprint for $\frac{1}{45000}$.
(*b*)	"	$= \frac{1}{48702}$	From Mitchell's formula quoted by Wollaston, Ph. Tr., 1829, p. 20.
(*c*)	"	$= \frac{1}{100000}$	Wollaston. Ph. Tr., 1829.
(*d*)	"	$= \frac{1}{16120000}$	Wollaston's formula. Ph. Tr., 1829, p. 20.
(*e*)	"	$= \frac{1}{389620}$	Euler's formula. Mem. Ac. Ber., 1750, p. 299.
(*f*)	"	$= \frac{1}{194810}$	Bouguer's formula. Mem. Ac. Paris, 1757, p. 22.
(*g*)	"	$= \frac{1}{97405}$	Bouguer, for sphere covered with polished hemispherical asperities. Mem. Ac. Paris, 1757, p. 22.
(*h*)	"	$= \frac{1}{210000}$	Leslie, Ed. Ph. Jour., No. XXII.
(*i*)	"	$= \frac{1}{50000}$	Smith. Optics.
(*j*)	"	$= \frac{1}{90000}$	Smith. Optics, p. 23.
(*k*)	"	$= \frac{1}{73054}$	Lambert's formula. Beer, Grund. Phot. Cal., p. 68.

Where the formulæ have been given, the values have been calculated, using for the Moon's mean semi-diameter seen from the Earth, 934″.67. It is probable that (*a*) and (*i*) have been derived from the same formula with (*b*) by employing a slightly different value of the Moon's semi-diameter; and a similar supposition may be made with respect to (*j*) compared with (*g*), and (*h*) compared with (*f*). However this may be, the difficulty with the formulæ (excepting (*d*), which does not seem to be a correct deduction from the principle assumed by Wollaston respecting the intensity of illumination on different parts of the Moon's surface) evidently lies with the values attributed to the coefficient Θ.

If we make $R = r$, $\frac{\rho}{\Delta} = \sin. 934''.67$, and $\mu = 1$, we have from (13)

$$\text{For } \Theta = 4 \qquad \frac{d\,i'}{d\,L} = \frac{1}{48702} \text{ as in } (b),$$

$$\text{“} = 2 \qquad \frac{d\,i'}{d\,L} = \frac{1}{97405} \text{ “ } (g),$$

$$\text{“} = 1 \qquad \frac{d\,i'}{d\,L} = \frac{1}{194810} \text{ “ } (f),$$

$$\text{“} = \tfrac{1}{2} \qquad \frac{d\,i'}{d\,L} = \frac{1}{389620} \text{ “ } (e),$$

$$\text{“} = \tfrac{8}{3} \qquad \frac{d\,i'}{d\,L} = \frac{1}{73054} \text{ “ } (k).$$

Referring to the particular cases considered on p. 233, we find that (*b*) represents the proportion of moonlight, if the Moon were a flat, opaque disc, reflecting light upon the surrounding concave in proportion to the apparent area of the disc as seen from different points; (*g*) is the proportion for a disc, reflecting, as in (7), with uniform intensity over the whole hemisphere to which it is presented; while (*f*) gives the proportion, supposing the Moon's surface polished.

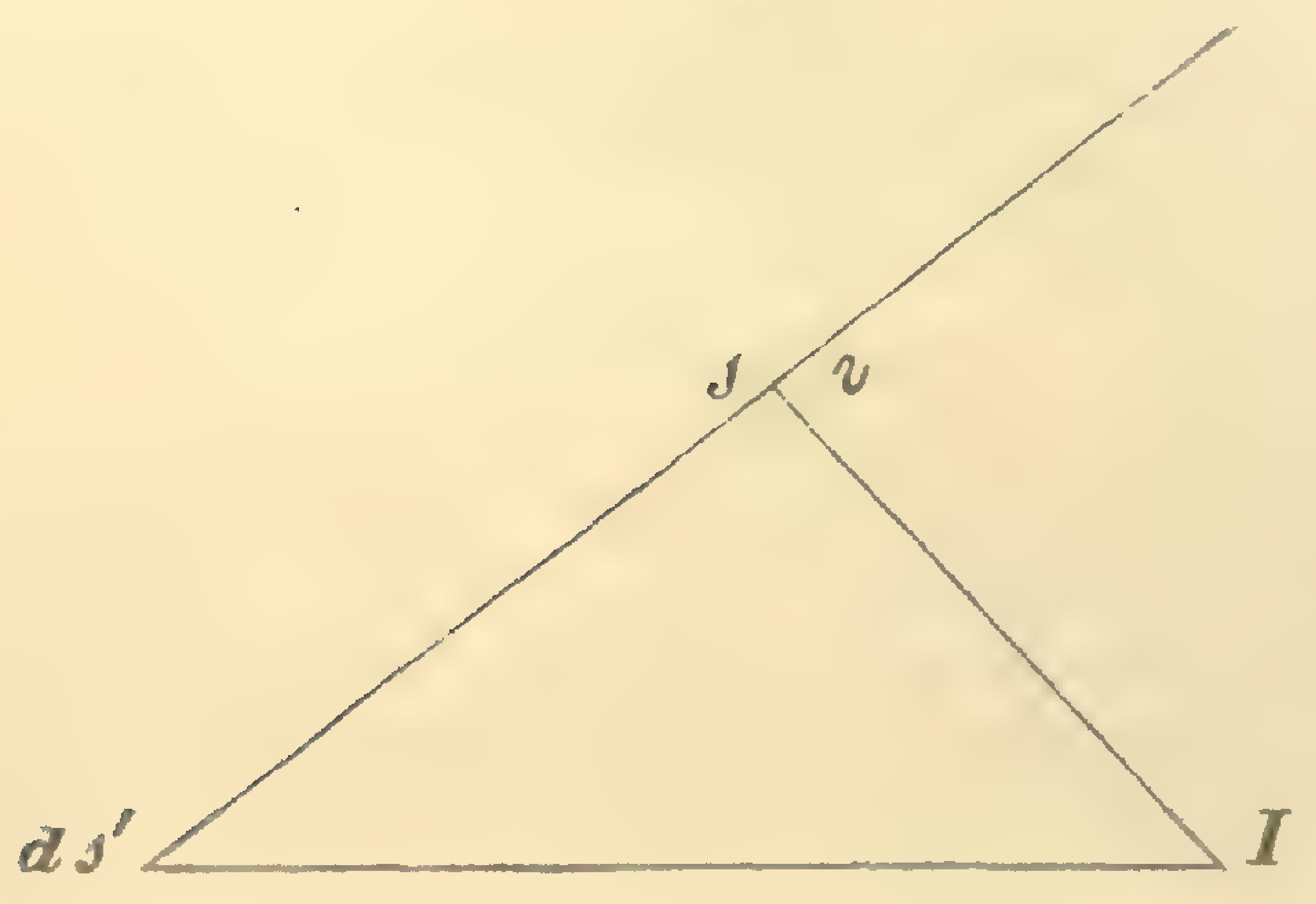
Euler's result implies the value $\Theta = \frac{1}{2}$, which is not at all probable. It will be noticed that he has supposed that an element, dS, of the surface of the Sun, or of any self-luminous body, diffuses its light in equal quantities in all directions. It would follow that a sphere self-luminous should appear near its margin, where each element, dS, is seen much foreshortened, proportionally brighter than at its centre; but this is not in reality true of the Sun,* nor of other bodies shining by their own light. If, on the other hand, equal areas are found experimentally to have the same apparent intensity at all angles of inclination of the surface to the line of sight,† the light from a self-luminous sphere like the Sun will be just one half as bright as it would be under Euler's hypothesis, if the intensity at perpendicular emission is the same in both instances, — being in the one case proportional to the projected area, and in the other, to the actual area of the visible hemisphere, or as

$$\frac{\pi\rho^2}{2\pi\rho^2} = \frac{1}{2},$$

ρ being the semi-diameter.

We will now consider the variations in the quantity of light reflected by the Moon or a planet produced by changes of phase, and shall find in the course of the investigation an explanation of the value $\Theta = \frac{8}{3}$. An element of its spherical surface presented at right angles to the parallel incident rays of the Sun, receives more light than an equal element would on any other part. The quantity received at other angles of incidence will vary as the cosine of the angle, and will vanish at the margin of the hemisphere. If the Moon is viewed from different positions, both the average brightness of the illuminated phase, and the relative intensity in different parts of it, will change with the angle between the line of sight and of

Fig. 1.



* Sir J. Herschel, Outlines of Astron., (395).

† Ibid., Treatise on Light. Enc. Met., p. 347. Beer, Grundriss des Photometrischen Calcüles, pp. 7, 8.

illumination. This angle, which is the external angle at s of the triangle $s\,I\,d\,s'$, Fig. 1, we will call v.

From the condition that the amount of sunlight incident upon any element of the illuminated hemisphere of the Moon is proportional to the cosine of the angle between the Sun and the zenith of that element, Lambert has obtained the expression *

$$(14)\qquad \frac{2\,\mu\,\sin.^2 l\,\sin.^2\sigma}{3\,\pi\,\sin.^2 s}\,(\sin.\,v - v\cos.\,v)$$

for the ratio of the light of the Moon, at any given phase, to that of the Sun.

l is the semi-diameter of the Moon seen from the element $d\,e$ on the Earth,
σ " " " Sun " " " " Moon,
s " " " Sun " " " " Earth.

If we substitute in (14),

$$\sin.\,l = \frac{\rho}{\Delta}, \qquad \sin.\,\sigma = \frac{\text{Sun's semi-diameter}}{r}, \qquad \sin.\,s = \frac{\text{Sun's semi-diameter}}{R},$$

it becomes

$$\frac{2\,\mu}{3\,\pi}\,(\sin.\,v - v\cos.\,v)\,\frac{R^2\rho^2}{\Delta^2 r^2}.$$

Comparing this with (13), we have

$$(15)\qquad \Theta = \frac{8}{3}\,\frac{\sin.\,v - v\cos.\,v}{\pi}, \qquad \frac{d\,i'}{d\,L} = \frac{2\,\mu}{3}\,\frac{\sin.\,v - v\cos.\,v}{\pi}\,\frac{R^2\rho^2}{\Delta^2 r^2},$$

as the expression, according to Lambert, of Θ and $\frac{d\,i''}{d\,L}$ for the phases of the Moon or for a planet partially illuminated. When $v = 180°$, $\Theta = \frac{8}{3}$, as on p. 235.

Euler,† on the other hand, gives a formula, which, reduced to the same notation, becomes

$$(16)\qquad \frac{d\,i'}{d\,L} = \frac{\mu\,\sin.^2\frac{1}{2}v}{8}\,\frac{R^2\rho^2}{\Delta^2 r^2};$$

hence,

$$\Theta = \frac{1}{2}\,\sin.^2\frac{1}{2}\,v.$$

The quantity of light received is here assumed to be proportional to the area of the illuminated phase, and the average intensity of its bright surface to be the same at all ages of the Moon, which is a condition not at all likely to hold good.

Lambert's solution is the only one ‡ which attempts to represent the gradation in the

* Photometria. Beer, Grund. des Phot. Cal., p. 69.

† Mem. Ac. Ber., 1750.

‡ Wollaston, Ph. Tr., 1829, has adopted the same principle, but he has deduced from it an erroneous formula for the full Moon, viz.:

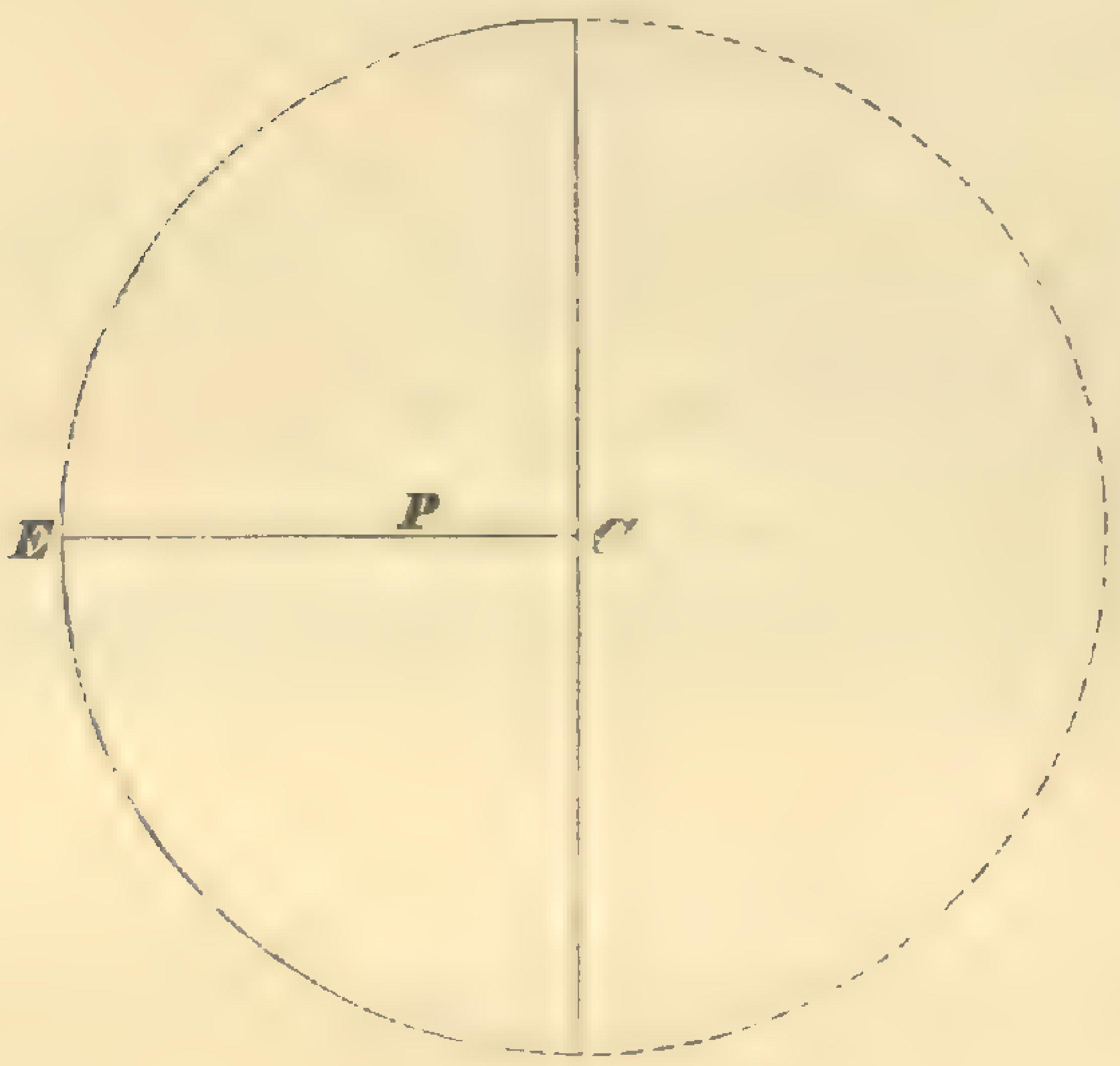
$$\frac{d\,i''}{d\,L} = \frac{1 + 2\sin.^3 l - \cos.^3 l}{3}.$$

intensity of the illumination of the phase from the edge presented towards the Sun up to the boundary between the bright and dark hemispheres. It is interesting to note, in the photographs of the Moon and Venus, when half enlightened, how much more sensitive to this graduation of intensity is the photographic plate than the eye.

Mr. De la Rue remarks that "the lunar surface, very near the dark limb, is copied photographically with great difficulty, and it sometimes requires an exposure five or six times as long, to bring out completely those portions illuminated by a very oblique ray, as others apparently not brighter."* The comparative feebleness of the edge near the dark part of the disc I have found to be most striking while the picture is developing.

He considers this to be an indication that there is an inequality in the chemical action of different parts of the Moon equally bright to the eye; and indeed it is difficult to convince one's self, from the impression produced on the retina, that the neighborhood of the unenlightened edge is relatively as deficient in optical as it is in chemical intensity. It is plain, however, that this inequality actually exists. If we view the Moon at quadratures when half enlightened, the quantity of sunlight incident on an element of its surface ds, placed so that its projection dp falls at P, on the semi-diameter CE, Fig. 2, will vary as the cosine of the angle between two lines, one drawn from the centre to the surface at E, where the Sun is in the zenith, and the other to the element ds. There is then a considerable region near the dark limb where the average visual intensity is not greater than one fifth or one sixth of that of the bright limb, just as is found to be the case photographically. Observations, which will be noticed in a subsequent part of this Memoir, prove that this diversity actually occurs in the distribution of light over the half-Moon, in accordance with the above theory, as well as with the photographic results.

Fig. 2.



The photographs of Venus exhibit the gradations of illumination over its surface very beautifully. The eye, indeed, with some attention, recognizes, in the telescopic view, a brightening up of its light on the limb next the Sun, but the contrast comes out much more decisively in the photographs.

It has been observed by De la Rue, that the high ground of the Moon's southern

* Report of the British Association, 1859, p. 145.

hemisphere is more easily photographed than the low lands of the northern hemisphere, and it has been supposed that this is another instance of a difference in chemical intensity which does not exist in the visual rays. The so-called lunar seas are certainly, optically as well as chemically, fainter than the rest of the surface, and the more rugged and mountainous regions are brighter to the eye, just as they are chemically. The eye is, however, likely to mislead in such estimates without special precautions to aid its judgment.

There is one peculiarity in the appearance of the full Moon, which deserves attention in this connection.

If the Moon were polished perfectly smooth, we should not see its limb at all, but only an image of the Sun, formed at a virtual focus by reflection from its surface; the visibility of its outline then is entirely due to its asperities, and the particular way in which these are disposed will have a great effect on the distribution of its light. Its surface ought, according to Lambert's investigation, to be brightest at the centre, and very decidedly faintest at the limb, but it is actually the reverse. We have before noticed the readiness with which the full Moon photographs at its margin, indicating the greater intensity of chemical light from that quarter; with a little attention, the eye recognizes the same property in the optical rays. When viewed at the proper time, the bright marginal rim of the full disc will be at once perceived, of nearly equal breadth throughout, say from 2′ to 3′, and reaching entirely round the circumference.

We have seen that Euler's view of the manner in which light emanates from the Sun requires that it should appear brightest at the circumference,* while Lambert makes the Moon brightest at the centre. In reality, these conditions are reversed, the Sun being brightest, and the Moon faintest, in the central regions. The condition of the Moon's surface, in this respect, seems to be an exception to the law of reflection from opaque substances, inferred experimentally by Lambert and Bouguer. It deserves notice, that the anomaly observed in the distribution of light over the lunar disc occurs also, though less decisively, in the planet Mars, which is ordinarily brightest at the limb when near its opposition. Possibly the Earth presents a like aspect viewed from a distance. In the daytime we see the sky near the horizon brighter than most terrestrial objects projected upon it. The light reflected from a great depth of dense atmosphere is therefore stronger than that reflected from the general landscape. The appearance of our Earth from a distance would be that of a dark body, seen through a thin, translucent atmosphere, which, if at the time free from clouds, will be at the edges

* Lambert considers the Sun to be uniformly bright over its disc.

brighter than the surface of the globe enveloped by it. Jupiter is brightest at the centre, but we perhaps never obtain a view of its solid nucleus, nor even of the denser regions of its atmosphere.

A more serious discordance from Lambert's formula is presented in comparing the observed and computed quantity of light received from the Moon at its several phases.

In 1836, Sir J. Herschel, during his stay at the Cape of Good Hope, compared the Moon's image, formed by a lens, by means of an apparatus constructed for the purpose, with sixty-nine of the brightest fixed stars, at various phases between the elongations 105° and 262°. The object immediately in view, which was the comparison of the light of the stars, by employing the lunar image merely as a temporary standard, and subsequently eliminating the uncertainty of its variations by referring all the stars to one of the brightest of their number, was satisfactorily accomplished, and furnished a most valuable series of photometric determinations. If the light of these stars be taken as an invariable standard, it is evident from Herschel's reductions, that that of the Moon experiences a much more rapid degradation at the phases on either side of full than can be accounted for by the formula* of which he has made use to correct the light received from the phase to full moonlight, and we shall presently see that Lambert's does not afford a materially better representation. On the other hand, if the moonlight, reduced to full, is assumed to be consistent with theory, then we must infer with Herschel, that the effect of the increasing phase on the general illumination of the sky enfeebles the starlight in a very anomalous way, and so as to make it impossible to obtain absolute results as originally proposed. He found that the influence in question might be represented by supposing that "the effective impression of a star on the retina is inversely as the square of the illumination of the ground of the sky on which it is seen projected,"† adding, however, that he was by no means prepared for the enormous extent of the influence which the results indicated.

Referring to the details of the investigation, it will be seen that, while the fact of a well-marked discrepancy is placed beyond doubt by Herschel's investigations, it may be accounted for equally well, so far as the representation of the observations is concerned, by ascribing it to actual variations of moonlight not recognized in the computed reductions. Thus, if, instead of supposing, with Euler and Herschel, that moonlight varies with the area of the projection of the illuminated surface presented to the Earth at a given phase, that is, as $\sin.^2 \frac{1}{2} v$ nearly, we adopt, within the limits of

* Results of Astr. Obs. at the Cape of Good Hope, p. 356. The formula is substantially the same as Euler's. See p. 237 (16).

† Ibid., p. 368.

the angles of elongation comprising the observations, a new expression nearly proportional to $\sin.^6 \frac{1}{2} v$, there will be no difficulty in satisfying the data. It should be noticed that this expression is not proposed as a substitute for Herschel's hypothesis, but merely to show that the observations in question can be satisfied without resorting to the latter. It will subsequently appear that neither of the formulæ represents the entire range of phases from new to full Moon.

The formula employed by Herschel, to find the proportion between the light from a given phase and that of the mean full Moon, may be derived from (12) by the following substitutions: —

M_1 = the light from the phase compared with the mean full Moon.
$d i''_0$ = the quantity of light from the mean full Moon, incident at right angles upon an element $d e$ at the Earth.
(17) r_0 = the corresponding distance of the Moon from the Sun.
Δ_0 = its mean distance from the Earth.
l_0 = its mean angular semi-diameter.
Θ = $\frac{1}{2} \sin.^2 \frac{1}{2} v$.
R = Earth's radius vector.

(12) then becomes, making at the full phase $v_0 = 180°$,

$$d i'_0 = \frac{\mu I}{32 \pi} \frac{\rho^2}{r^2_0 \Delta^2_0} d e, \qquad d i' = \frac{\mu I}{32 \pi} \frac{\rho^2}{r^2 \Delta^2} \sin.^2 \tfrac{1}{2} v \, d e,$$

and we shall have

(18) $$M_1 = \frac{d i''}{d i''_0} = \frac{r_0^2 \Delta_0^2}{r^2 \Delta^2} \sin.^2 \tfrac{1}{2} v,$$

in which may be used

$$r_0 = 1.0025 \qquad \frac{\Delta_0}{\Delta} = \frac{l}{l_0},$$
$$r = R\,(1 - 0.0025 \cos. v)$$

l being the augmented semi-diameter as seen from $d e$. The difference between the Moon's semi-diameter seen from $d e$ and from the centre of the Earth, as well as the difference between the distance of the Earth and of the Moon from the Sun, are, however, too small to have an appreciable influence upon the experiments.

By the same substitutions, but making

$$\Theta = \tfrac{1}{2} \sin.^6 \tfrac{1}{2} v,$$

we have

(19) $$M_2 = M_1 \sin.^4 \tfrac{1}{2} v.$$

The value of M best representing the observations between quadratures and opposition, when the light of the stars is taken as the standard, is, according to Herschel

$$M_3 = M_1^{\,2.98},$$

or very nearly

(20) $$M_3 = M_1^3.$$

According to Lambert's formula, we shall find from (15) and (12)

(21) $$M_4 = \frac{r_0^2 \Delta_0^2}{r^2 \Delta^2} \frac{\sin. v - v \cos. v}{\pi} = M_1 \frac{\sin. v - v \cos. v}{\pi \sin.^2 \frac{1}{2} v}.$$

Hence we have

(22)

$$M_1 = \frac{r_0^2 \Delta_0^2}{r^2 \Delta^2} \sin.^2 \frac{1}{2} v.$$ Euler and Herschel.

$$M_2 = M_1 \sin.^4 \frac{1}{2} v.$$ Assumed.

$$M_3 = M_1^3.$$ "

$$M_4 = M_1 \frac{\sin. v - v \cos. v}{\pi \sin.^2 \frac{1}{2} v}.$$ Lambert.

These will be compared with the results of Herschel's observations. In the first column of the following statement, the date of the observation is given; in the second, the number of stars compared with the Moon; in the third, its elongation from the Sun; in the fourth, the logarithm of the observed moonlight; in the fifth and sixth, the altitude and corresponding log. cor. for extinction; next, the logarithm of the observed quantity of moonlight corrected for extinction, and referred to the mean full Moon as a unit, with the weight given to the determination; in the remaining columns are the values of the logarithms of M_1, M_2, etc., calculated according to the above hypotheses. M_0 has been derived from Herschel's log. μ^*,* by subtracting the constant logarithm 3.500, and applying a correction for atmospheric extinction.

$$\log. M_0 = \log. \mu^* - 3.500 + \log. \text{cor. for extinction.}$$

In the correction for extinction, which corresponds to the altitude adopted in the adjacent column, it has been assumed that the average altitude of the stars was the same as that of the Moon. Its influence is at all events scarcely appreciable, excepting in one or two instances. It will be seen from the comparisons which follow, that the constant 3.500 applied as above to log. μ^* is a sufficient approximation for the present purpose. The value 3.543 was subsequently found, but its introduction would not affect the conclusions arrived at.

* Herschel's μ is here designated as μ^*, to distinguish it from the same letter used with a different signification elsewhere in this Memoir.

Date. 1836.	No. of Stars.	Moon's Elongation.	Log. Obs. Moonlight.	Alt.	Log. Cor. Extinction.	Log. M_0.	Wt.	Log. M_1.	Log. M_2.	Log. M_3.	Log. M_4.
Mar. 28	19	129°.5	9.499	30°	0.097	9.596	2	9.896	9.721	9.688	9.830
30	20	154.6	9.751	47	.024	9.775	3	9.985	9.942	9.954	9.966
31	4	167.0	0.017	50	.017	0.034	2	0.012	0.000	0.035	0.006
April 1	5	179.3	0.213	55	.010	0.223	2	0.023	0.023	0.069	0.023
3	14	201.0	9.956	70	.003	9.959	5	0.024	9.995	0.971	0.011
4	13	221.4	9.786	76	.002	9.788	2	9.981	9.865	9.944	9.937
7	6	261.9	9.304	50	.017	9.321	3	9.786	9.299	9.359	9.625
26	13	120.9	9.582	44	.030	9.612	5	9.868	9.626	9.603	9.786
27	20	134.2	9.720	50	.017	9.737	5	9.932	9.790	9.796	9.884
June 29	5	193.0	0.059	45	.028	0.087	4	0.039	0.028	0.012	0.048
July 22	9	105.2	9.506	70	.003	9.509	4	9.813	9.413	9.440	9.690
24	8	133.2	9.832	55	.012	9.844	4	9.960	9.811	9.881	9.917
26	13	160.7	9.026	83	.001	0.027	5	0.030	0.005	0.089	0.032
Aug. 22	3	130.0	9.794	55	.012	9.806	3	9.949	9.779	9.848	9.894
23	5	143.0	9.885	74	.002	9.887	4	9.991	9.899	9.972	9.962
Nov. 19	12	142.1	9.786	45	.028	9.814	4	9.952	9.855	9.855	9.902
25	2	211.4	9.625	29	.113	9.738	2	9.933	9.867	9.800	9.894
Dec. 17	4	123.0	9.504	37	.058	9.562	3	9.884	9.659	9.651	9.787
26	3	223.6	9.740	30	0.097	9.837	2	9.905	9.776	9.714	9.844

From the above we obtain the following, arranged according to values of v.

	Log. M_1 — log. M_0.	Log. M_2 — log. M_0.	Log. M_3 — log. M_0.	Log. M_4 — log. M_0.	Wt.
$v =$ 98°.1	+0.465	—0.022	+0.038	+0.304	3
105.2	+0.304	—0.096	—0.069	+0.181	4
120.9	+0.256	+0.014	—0.009	+0.174	5
123.0	+0.322	+0.097	+0.089	+0.225	3
129.5	+0.300	+0.125	+0.092	+0.234	2
130.0	+0.143	—0.027	+0.042	+0.088	3
133.2	+0.116	—0.033	+0.037	+0.073	4
134.2	+0.195	+0.053	+0.059	+0.147	5
136.4	+0.068	—0.061	—0.123	+0.007	2
138.6	+0.193	+0.077	+0.156	+0.149	2
142.1	+0.138	+0.041	+0.041	+0.098	4
143.0	+0.104	+0.012	+0.085	+0.075	4

	Log. M_1 — log. M_0.	Log. M_2 — log. M_0.	Log. M_3 — log. M_0.	Log. M_4 — log. M_0.	Wt.
$v = 148°.6$	+0.195	+0.129	+0.062	+0.156	2
154.6	+0.210	+0.167	+0.179	+0.191	3
159.0	+0.065	+0.036	+0.112	+0.052	5
160.7	+0.003	−0.022	+0.062	+0.005	5
167.0	−0.022	−0.034	+0.001	−0.028	2
167.0	−0.048	−0.059	−0.075	−0.039	4
179.3	−0.200	−0.200	−0.154	−0.200	2

It is plain that M_2 and M_3 alone furnish a tolerably approximate representation of the data. The agreement of these is good, considering the difficulties of the observations. The largest discrepancy is for the full Moon, $v = 179°.3$; unfortunately, it is the only determination for this phase, and, the sky at the time being partially clouded, only a small weight can be given to the observation.

To decide the question of preference between M_2 and M_3, if we divide the results into groups of adjacent values of v, and take the means according to weights, we have

		Log. M_2 — log. M_0.	Log. M_3 — log. M_0.
$v = 102°.2$	$\Sigma w = 7$	−0.064	−0.023
121.7	" = 8	+0.045	+0.028
131.3	" = 9	+0.004	+0.051
135.7	" = 9	+0.033	+0.040
143.7	" = 10	+0.047	+0.063
158.7	" = 13	+0.044	+0.108
167.0	" = 6	−0.051	−0.025
179.3	" = 2	−0.200	−0.154

$$\sqrt{\frac{\Sigma w\,(\log. M_2 - \log. M_0)^2}{\Sigma w}} = \pm\, 0.056, \qquad \sqrt{\frac{\Sigma w\,(\log. M_3 - \log. M_0)^2}{\Sigma w}} = \pm\, 0.067.$$

Of the two hypotheses, then, for the quantity of moonlight between the limits $v = 102°$ and $v = 179°$,

$$M_2 = \frac{r_0^2\,\Delta_0^2}{r^2\,\Delta^2}\,\sin.^6 \frac{1}{2}\,v, \qquad M_3 = \frac{r_0^6\,\Delta_0^6}{r^6\,\Delta^6}\,\sin.^6 \frac{1}{2}\,v,$$

the first is at least as good as the second. This proves that the apparent increase of brightness towards the full Moon is not *necessarily* due to a relative enfeeblement of

starlight by the illumination dispersed over the sky, but may, with equal probability, be referred to some peculiarity in the Moon itself, which causes it to reflect light more freely at some inclinations of the incident and visual rays than at others.

This result, taken in connection with the wide divergence of Euler's and Lambert's formula, making the Moon at quadratures, theoretically, twice as bright as it really is, gives a new interest to the investigation, and makes it desirable that it should be subjected to other tests. One such is afforded in the following considerations.

If it is true that a change in the brightness of the background of the sky has the effect of enfeebling the impression of starlight on the eye, in so high a ratio as the square of the diffused illumination, the fact should appear on dividing the observations of the stars compared into two groups, one comprising those made at a large angular distance from the Moon, and the other, those nearest to it; the latter should afford results making the stars relatively fainter, in consequence of the greater intensity of illumination of the sky in the immediate neighborhood of the Moon.

The following stars in Herschel's series are favorably situated for showing the influence in question.

Name of Star.	Distance from Moon.	Observed Quantity of Light.
θ Scorpii	37°	0.169
"	48	0.150
"	100	0.170
λ Scorpii	45	0.202
"	100	0.196
ε Sagittarii	40	0.145
"	52	0.147
α Centauri	40	0.930
"	43	1.235
"	43	1.120
"	62	1.095
β Centauri	40	0.440
"	44	0.370
"	45	0.407
"	65	0.400
"	65	0.382
α Gruis	33	0.194
"	38	0.185
"	65	0.163
α Pavonis	33	0.155
"	47	0.132
"	72	0.139

For the quantity of light, the numbers are given as computed by Herschel, by a process explained in the work above cited,* which gives the brightness of each individual star in parts of a common unit, and freed from the average of the perturbations common to all the stars observed on any one night. Those dates only have been employed for the purpose now in view, which afford a sufficient number of stars for a reliable mean value of μ^*; with this precaution, the peculiarities appertaining to each star, on any one night, ought to discover themselves.

In the following results, the column headed "Relative Brightness" is the ratio between the light of the star determined at the smaller of the two distances from the Moon, compared with the light of the same star when at the greatest distance.

Name of Star.	Distances from Moon.		Relative Brightness.	Wt.
θ Scorpii	37°	100°	1.00	3
	48	100	0.88	
λ Scorpii	45	100	1.03	5
ε Sagittarii	40	52	0.98	1
α Centauri	42	62	1.00	3
β Centauri	43	65	1.04	4
α Gruis	35	65	1.17	3
α Pavonis	40	72	1.04	4
Mean by Weights	42	78	1.02 ± 0.011	

This result does not indicate any appreciable influence from the greater amount of diffused illumination of the sky in the neighborhood of the Moon, and is, therefore, unfavorable to the hypothesis that the abnormal variations of brightness of the stars relatively to the Moon, from night to night, are to be explained by an increase in the quantity of moonlight dispersed by reflection in the atmosphere, over the whole sky.

We have already seen that photographic experiments indicate a peculiarity in the chemical action of moonlight at the several phases compared with the full, and from the above discussion it would seem that the visual rays are affected in an analogous manner, and to an extent not accounted for in Euler's nor in Lambert's theory, — in other words, the brightness of the Moon increases too rapidly between the half-moon and the full phases.

In order to leave no doubt as to the reality of the discrepancy between the amount of light actually received from the phases and that indicated by the proposed theories, and of its being properly referable to the Moon itself, I have compared the latter with a fixed

* Results of Astronomical Observations, Cape of Good Hope, p. 365.

standard, by a process quite different from Herschel's, extending the experiments also to the phases between conjunction and quadratures.

I have used, as a standard light, a little disc of the central part of the flame of a Carcel lamp. The height of the flame being first regulated to its maximum of $1^{in}.50$ to $1^{in}.75$ from the top of the wick, a tube of zinc was placed outside of the chimney, at a distance of 1 inch from the nearest part of the flame, and high enough to cut off all the light excepting that which passed through apertures made in the zinc for the purpose; these apertures were circular holes of the following diameters: —

		in.
Diaphragm	X	0.094
"	Y	0.056
"	Z	0.040
"	M	0.033

They were placed in turn opposite to the part of the flame which appeared of most uniform brightness. By using, in this way, only a small area of the middle of the flame, its variations in height were made much less sensible than they would otherwise have been.

To compare the light transmitted through the aperture with the Moon, the light of both objects was received on a glass globe, either silvered or filled with mercury, and their images, viewed side by side, were equalized by moving the bulb to the proper distance from the lamp. This distance being always large compared with the radius of the bulb, the brightness of the two objects will be as the squares of their distances from the bulb.

The following are the diameters of the glass spheres used in these and subsequent experiments.

		Diameter of Reflecting Surface. in.
B_1	Filled with mercury (thermometer bulb), ...	0.604
B_2	Silvered, ...	3.436
B_3	Silvered, ...	1.760
B_4	Filled with mercury (thermometer bulb), ...	0.304
B_5	Silvered, ...	10.160

These refer to the inner reflecting surface of each, twice the thickness of the glass having been subtracted from the outside diameters. The spherical form was well preserved throughout the surface of the bulbs, excepting near the stem, a part not used in the experiments.

The following diameters of B_2, measured in various directions, show the general character of the irregularities of figure to which these glass globes are liable.

Diameter of B_2 =	in. 3.501	— 2 ×	in. 0.034
	3.506		"
	3.500		"
	3.503		"
	3.510		"

Small irregularities of form and in the quality of the reflecting surface are eliminated by reversing the bulb, so as to present the same part alternately to each object. The absorption being equal for both images, its effect will be eliminated in the ratio of the two lights compared.

The convenience of this photometer is its principal recommendation, especially when the observations are made at night and in the open air, under various annoyances which would prevent the use of any but a very simple apparatus. A polished sphere has the property of reflecting an equally bright image of a distant object in all directions; but since the proportion of light lost by absorption may be liable to vary somewhat at different incidences, it is better to place the eye in such a position for viewing the two images, that a line drawn from it to the centre of the sphere may make equal angles with the directions of the two objects from the same centre, so that the angles of incidence for the light reaching the eye will thus be the same for both.

Care has been taken to place the bulb in the axis of the pencil proceeding from the lamp aperture, so that the light compared should come from the centre of the flame, and pass the aperture at nearly right angles to its plane.

If $d\,l$ be the quantity of light incident from the lamp disc upon an element of surface $d\,e$, placed near the axis of the pencil, and perpendicular to the line d, joining $d\,e$ with the centre of the disc, $d\,l$ will remain sensibly constant for small changes in the direction of d relatively to the axis. The whole quantity of light, incident upon a sphere having a radius β, small compared with d, will then be obtained, as in (10).

$$(23) \qquad i = \frac{l}{4}\,\frac{\beta^2}{d^2};$$

where l is the whole quantity of light which would emanate from the disc, if it shone in all directions with the same brightness that it does upon $d\,e$ when placed in the axis of the pencil. So long as the comparisons are confined to the light incident from the

illuminating aperture, near the axis of the pencil, we may proceed with the reductions as though this were actually the case.

From (12) we have for the moonlight, incident at right angles upon $d\,e$,

$$d\,i' = \frac{\Theta\,\mu\,I}{16\,\pi}\,\frac{\rho^2\,d\,e}{r^2\,\Delta^2}\,, \tag{24}$$

ρ being the Moon's radius, r and Δ its distance from the Sun and Earth. The quantity incident upon the bulb, denoted by i', will be obtained by substituting for $d\,e$ the area of its section, by a plane perpendicular to Δ, or $d\,e = \pi\,\beta^2$, whence

$$i' = \frac{\Theta\,\mu\,I}{16}\,\frac{\rho^2\,\beta^2}{r^2\,\Delta^2}. \tag{25}$$

By the equalization of the images of the Moon and lamp upon the bulb, we have $i = i'$, and from (23),

$$\frac{l}{d^2} = \frac{\Theta\,\mu\,I}{4}\,\frac{\rho^2}{r^2\,\Delta^2}. \tag{26}$$

The light of the Moon for any particular value, v_1, of v, and at the distances Δ_1 and r_1 from the Earth and Sun, gives

$$\frac{l}{d_1^2} = \frac{\Theta_1\,\mu\,I}{4}\,\frac{\rho^2}{r_1^2\,\Delta_1^2}; \tag{27}$$

Θ_1 and d_1 being the corresponding values of Θ and d. Comparing (26) and (27), we find, by making $H_1 = \frac{\Theta}{\Theta_1}$,

$$H_1 = \frac{d_1^2}{d^2}\,\frac{r^2\,\Delta^2}{r_1^2\,\Delta_1^2}. \tag{28}$$

The values of H_1 must be derived from observation at different ages of the Moon; we shall then have from (24), for the quantity of moonlight at any phase, and for given values of r and Δ compared with the assumed standard,

$$\frac{d\,i'}{d\,i'_1} = H_1\,\frac{r_1^2\,\Delta_1^2}{r^2\,\Delta^2}. \tag{29}$$

The following are the observations made for the purpose of determining H_1, the mean quantity of moonlight at the several phases; d represents the distance of the centre of the bulb from the diaphragm of the lamp. In these and in subsequent experiments, four Carcel lamps, distinguished by the letters *I*, *R*, *S*, and *W*, were used, with hollow cylindrical flames, the oil being supplied at the lower edge of the flame by clockwork. A few comparisons of Jupiter and Venus, taken at the same time, are included.

Photometric Observations upon the Moon, Jupiter, and Venus.

1860, March 24th. Lamp *S*, diaphragm **Z**. "A few clouds near the horizon, but the sky seems perfectly clear in the intervals."

h m					ft.
8 3	Sidereal time.	Moon $2\frac{1}{2}$ days old.	"A cloud not far off, 10° or 15° from Moon."	d =	38.5
8 4	"	" "	" " "	d =	38.5
8 21	"	" "	"Perfectly clear."	d =	36.0
8 6	"	Venus.		d' =	66.0
8 10	"	"		d' =	47.0
8 23	"	"		d' =	47.0
8 12	"	Jupiter.		d'' =	93.5
8 19	"	"		d'' =	98.5
8 26	"	"		d'' =	108.5

The position of the lamp was thought rather too high, and was altered on the subsequent evenings; this, if at all sensible, would cause the Moon, Venus, and Jupiter to appear too bright on the 24th. The equalization of the images was noted by two observers, the position of the bulb being frequently changed. The chief uncertainty arises from the red color of the flame when contrasted with the Moon and planets, though when seen by itself it looks quite white. The Moon was only about 8° above the horizon.

March 25th. Lamp *S*, diaphragm **Z**. "Cleared suddenly. A pure sky, and the 'lumière cendrée' unusually distinct."

h m					ft.
7 54	Sid. time.	Moon $3\frac{1}{2}$ days old, near Venus.	A thin cloud was noticed just below the two when the observations were commenced, but it soon dispersed.	d =	10.6
7 50	"	" "		d =	9.0
8 8	"	" "		d =	12.1

7h 56m	Sidereal time.	Venus.		$d' = 50.6$ ft.
8 23	"	"		$d' = 61.1$
8 5	"	Jupiter.		$d'' = 93.6$
8 9	"	"		$d'' = 93.4$
8 19	"	"	"Perfectly clear."	$d'' = 94.9$

March 27th. Perfectly clear.

9h 2m	Sid. time.	Moon 5½ days old.	Diaphragm Z.	$d = 5.14$ ft.
9 5	"	" "	"	$d = 5.65$
9 8	"	" "	"	$d = 5.63$
9 10	"	" "	Diaphragm X.	$d = 12.10$
9 11	"	" "	"	$d = 11.60$
9 12	"	" "	"	$d = 12.10$
9 15	"	" "	Lamp without diaphragm. Average height from wick 1in.50, to apex 1in.75.	$d = 113.06$

To reduce the comparisons made with X to the standard aperture Z, the ratio

$$\frac{\text{Light from Z}}{\text{Light from X}} = \frac{1}{4.63},$$

as determined by experiment, is to be used.

1860, March 29th. Clear.

9h 00m	Sid. time.	Moon, first quarter.	Diaphragm X.	$d = 5.44$ ft.
"	"	" "	"	$d = 5.77$
"	"	" "	"	$d = 5.82$
"	"	" "	Full flame without diaphragm.	$d = 65.6$
			Mean height from wick 1in.68, to extreme apex 2in.10.	$d = 63.1$

The hour was not noted, but it was nearly as stated.

March 30th. "A red haze in the sky, which does not appear to obstruct the light much." *

10h 14m	Sid. time.	Moon 8½ days old.	Diaphragm X.	$d = 5.95$ ft.
"	"	" "	"	$d = 6.50$
"	"	" "	"	$d = 6.48$

There was no glass screen before the lamp disc, and to reduce the observations to the usual standard, the lamp-light must be multiplied by the coefficient $\gamma = \frac{6}{7}$, as well as by the ratio of Z to X, given under the date of March 27th.

* It appears, from the reductions, that the effect of the haze was more considerable than was at first supposed.

April 2d. Perfectly clear. No clouds visible through the evening.

8h 19m	Sid. time.	Venus.	Diaphragm Z.		d′ = 45.3 ft.
"	"	"	"		d′ = 44.5
8 29	"	Jupiter.	"	Owing to moonlight, the image of Jupiter had become too faint for a reliable comparison.	d″ = 64.5
8 49	"	Moon 11½ days old.		Lamp, diaphragm X, without screen.	d = 3.20
"	"	"	"		d = 3.13
"	"	"	"		d = 3.60
8 54	"	"	"		d = 3.10

The above observations on the Moon must be corrected, as on March 30th, by the coefficient γ. Later in the evening the lamp *I* was placed in position as used for Venus and Jupiter, with the screen, but having no diaphragm; the flame adjusted to a height of $0^{in}.75$ from wick, and subsequently compared with standard, gave

$$\text{Log.}\ \frac{\text{Z}}{\text{Lamp-flame } 0^{in}.75} = 7.8054.$$

12h 59m	Sid. time.	Moon with lamp *I*, as above.	d = 14.4 ft.
		" "	d = 15.4

April 5th. A thin haze about the horizon, with cirrus cloud. The sky near the Moon appeared clear, though not perfectly transparent. Lamp *I* in usual position, flame adjusted to a height of $0^{in}.96$, and subsequently compared with standard.

$$\text{Log.}\ \frac{\text{Z}}{\text{Lamp-flame } 0^{in}.96} = 7.4519.$$

11h 33m	Sid. time.	Moon with lamp *I*, as above.	d = 17.9 ft.
11 36	"	" "	d = 19.2
11 39	"	" "	d = 19.3

April 6th. Clear.

Lamp *S* in usual position. Low flame. By comparison with standard,

$$\text{Log.}\ \frac{\text{Z}}{\text{Lamp } S} = 7.6954.$$

14h 39m	Sid. time.	Moon near meridian; one day past full.	d = 18.0 ft.
		" " " "	d = 13.8
		" " " "	d = 13.4
		" " " "	d = 13.7
		" " " "	d = 13.8

April 13th. Fine sky. Perfectly clear.

9^h 54^m Sid. time.	Venus.	Diaphragm Z.	Lamp *S.*		$d =$ 51.9 ft.
	"	"	"		$d =$ 50.6
10 4 "	Jupiter.	"	"		$d =$ 106.6
	"	"	"		$d =$ 105.8
	"	"	"		$d =$ 108.4

April 18th. Perfectly clear.

9^h 34^m Sid. time.	Venus (half enlightened).	Lamp *S.*	Diaphragm Z.	$d =$ 40.0 ft.
9 54 "	" "	"	"	$d =$ 40.5
9 49 "	" "	"	"	$d =$ 99.6

May 2d. Clear, but not entirely free from haze.

12^h 45^m Sid. time.	Moon 2 days before full; near the meridian.	Lamp *S.*	Diaphragm X.	$d =$ 2.75 ft.
	" " "	"	"	$d =$ 2.45
	" " "	"	"	$d =$ 2.55
	" " "	"	"	$d =$ 2.95
	" " "	Lamp *I.*	"	$d =$ 2.35
	" " "	"	"	$d =$ 2.45
	" " "	"	"	$d =$ 2.35
	" " "	"	"	$d =$ 2.55

May 4th. Thin, red haze, dense at horizon.

13^h 15^m Sid. time.	Moon full.	Lamp *S.*	Diaphragm X.	$d =$ 3.06 ft.
	"	"	"	$d =$ 2.76
	"	"	"	$d =$ 2.66

May 25th. Clear.

12^h 32^m Sid. time.	Moon 5 days old.	Lamp *S.*	Diaphragm X.	$d =$ 9.3 ft.
	"	"	"	$d =$ 10.2
	"	"	"	$d =$ 10.4
12 54 "	"	"	"	$d =$ 9.3
	"	"	"	$d =$ 9.8
	"	"	"	$d =$ 9.3

May 28th. Clear.

13^h 39^m Sid. time.	Moon 8 days old.	Lamp *S.*	Diaphragm X.	In open air.	$d =$ 4.5 ft.
	"	"	"	"	$d =$ 4.0
	"	"	"	"	$d =$ 3.8

Correction γ to be applied as on March 30th.

$13^h\ 49^m$	Sid. time.	Moon 8 days old.	Lamp *S*.	Diaphragm **X**.	In open air.	$d = \overset{ft.}{3.5}$
		"	"	"	"	$d = 4.0$
		"	"	"	"	$d = 4.1$
14 14	"	"	"	"	With screen.	$d = 4.90$
		"	"	"	"	$d = 4.60$
		"	"	"	"	$d = 4.75$
14 19	"	"	"	"	"	$d = 4.8$
		"	"	"	"	$d = 4.7$
		"	"	"	"	$d = 4.8$

June 2d. Perfectly clear.

$17^h\ 40^m$	Sid. time.	Moon half a day from full.	Lamp *S*.	Diaphragm **X**.	With screen.	$d = \overset{ft.}{2.20}$
		" "	"	"	"	$d = 2.40$
		" "	"	"	"	$d = 2.30$

June 12th. Clear.

$14^h\ 15^m$	Sid. time.	Venus.	Lamp *S*.	Diaphragm **X**.	With screen.	$d' = \overset{ft.}{63.8}$
		"	"	"	"	$d' = 63.8$

In the reductions, we must allow for the proportion of light extinguished by the atmosphere, taking the light when the object is in the zenith as a standard. To do this, the light as observed must be multiplied by a coefficient ε, the numerical values of which have been adopted from Seidel. These must be applied, together with the coefficient γ, as mentioned in the notes appended to the observations on March 30th, April 2d, and May 28th. The comparisons made with other apertures, as with **X**, or with the whole flames, must be reduced, as directed in the notes. The amount of illumination afforded by the aperture **Z** at the axis of the pencil, is considered to be constant at the same distance.

The object of the investigation, as respects the Moon, is to find H_1, by applying the formula (28). The observations upon Jupiter and Venus are not numerous enough to exhibit the variations of phase, but will furnish normal values of d_1' and d_1'', by means of which their light may be compared with moonlight.

Let

d_1 = The distance in feet from the aperture **Z**, at which the illumination from the lamp is equal to that received from the standard phase of the Moon.

d_1' = The corresponding distance for Venus.

d_1'' = The corresponding distance for Jupiter.

For the Moon.	For Venus.	For Jupiter.
$r_1 = 1.0000$	$r_1' = 0.7233$	$r_1'' = 5.2028$
	$\Delta_1' = 1.0000$	$\Delta_1'' = 4.2028$
	$v_1' = 111°.2$	$v_1'' = 180°$

The standard phase for Venus accords nearly with the date 1860, April 1st, $23^h.5$, mean solar time at Cambridge; this has been adopted on account of its lying midway between the dates of observation, so that errors in the assumed values of the corrections for phase,

$$H_1' = \frac{\theta_1}{\theta_1'}, \tag{30}$$

which must be used to find a normal value of d_1', will be mostly eliminated. I have used

$$H_1' = \frac{\sin. v' - v' \cos. v'}{\sin. v_1' - v_1' \cos. v_1'}, \qquad H_1'' = \frac{\sin. v'' - v'' \cos. v''}{\sin. v_1'' - v_1'' \cos. v_1''},$$

for the reductions to the standard phases of Venus and Jupiter respectively; the light of the latter being referred to its mean opposition as a standard.

The observations upon the Moon have been referred to its mean distance from the Earth, using for its mean semi-diameter, 934″.67.

After applying all the corrections, we have the following results:—

1860.	Moon.			Venus.			Jupiter.		
March 24	$v = 27°$	log. $\frac{H_1}{d_1^2}$ =	7.111	$v' = 111°.2$	log. $\frac{1}{d_1'^2}$ =	6.760	$v'' = 180°$	log. $\frac{1}{d_1''^2}$ =	6.162
25	39	"	8.158	"	"	6.713	"	"	6.129
27	64	"	{ 8.605 8.594			....			....
29	87	"	9.147			....			....
30	100	"	9.113			....			....
April 2	142	"	{ 9.665 9.839	"	"	6.811	"	"	[6.573]
5	176	"	0.029			....			....
6	162	"	0.046			....			....
13	...		....	"	"	6.793	"	"	6.221
18	...		....	"	"	6.872	"	"	6.267
May 2	150	"	{ 9.910 9.825			....			....
4	178	"	9.884			....			....
25	66	"	8.731			....			....
28	106	"	{ 9.958 9.367			....			....
June 2	174	"	0.147			....			....
12	...		....	"	"	6.646			....

A graphical projection of the values of log. $\frac{H_1}{d_1^2}$ gives $d_0 = 0^{ft}.9705$ for the distance from the disc **Z** at which its illumination is equal to that received from the mean full Moon. Substituting d_0, we may derive from the above, normal values of log. H_0 or the logarithms of the quantity of light received from the various phases of the Moon at its mean distance from the Earth and Sun, taking the light of the mean full Moon as the unit.

$v = 0°$	Log. $H_0 = -\infty$
20	" 7.224
40	" 8.049
60	" 8.574
80	" 8.974
100	" 9.291
120	" 9.551
140	" 9.769
160	" 9.931
180	" 0.000

In order to compare these with the results derived from Herschel's observations, we must subtract from the logarithms of the Moon's apparent brightness the constant 3.543, representing the light of the mean full Moon according to his scale, and apply the proper corrections for reducing the amount of moonlight on each date to the mean distances of the Moon from the Earth and from the Sun. There are not sufficient data, precisely at the opposition, among the Cape observations, for a direct calculation of this constant, but it may be inferred from the whole series of their differences* from log. H_0.

The comparisons which may be used for this purpose are as follows:—

	Log. H_0.	Cape Obs.	Diff.	Wt.
$v = 102°.2$	9.324	9.368	−0.044	7
121.7	9.574	9.560	+0.014	8
131.3	9.681	9.711	+0.030	9
135.7	9.724	9.725	−0.001	9
143.7	9.805	9.778	+0.027	10
158.7	9.920	9.868	+0.052	13
167.0	9.964	9.991	−0.027	6
179.3	0.000	0.157	−0.157	2

* Results of Astronomical Observations, Cape of Good Hope, p. 367.

With the exception of the last, which depends, as has already been remarked, upon an isolated observation, made with the sky partially clouded, there is a satisfactory agreement between the two series. It will be interesting to compare with the above results from observation the following values furnished by the formulæ of Lambert and Euler, and the empirical formula (22), which, as we have seen, represents the changes from the half to full Moon with tolerable precision.

		Lambert.	Euler.	
	Obs'd log. H_0.	Log. $\frac{\sin. v - v \cos v}{\sin. v_0 - v_0 \cos. v_0}$.	Log. $\sin.^2 \frac{1}{2} v$.	Log. $\sin.^6 \frac{1}{2} v$.
$v =$ 0	$-\infty$	$-\infty$	$-\infty$	$-\infty$
20	7.224	7.653	8.749	5.438
40	8.049	8.536	9.068	7.204
60	8.574	9.037	9.398	8.194
80	8.974	9.374	9.616	8.848
100	9.291	9.613	9.768	9.305
120	9.551	9.785	9.875	9.625
140	9.769	9.903	9.946	9.838
160	9.931	9.975	9.987	9.960
180	0.000	0.000	0.000	0.000

It is plain that neither of the theoretical expressions accords with the observations, though the last is barely tolerable between $v = 90°$ and $v = 180°$. Lambert's, which succeeds better in the whole range from new Moon to full, still makes the half-Moon from two to three times too bright. And if his theory is true for most opaque substances, it would seem, as has been already remarked, that, in the disposition of the asperities which reflect the sunlight from its surface, the Moon has a peculiar constitution. This, too, is indicated in the fact, that the borders of the full Moon are disproportionately bright, contrasted with the centre. It deserves attention, in connection with the subject, that Secchi* has noticed a peculiarity in the polarization of moonlight, which he compares to that observed in reflection from glass-paper. It may be worth while to notice, too, that the Moon is little if at all exposed to the disintegrating action of water or of an atmosphere; hence it is not unlikely that its surface, instead of presenting the dull, weather-worn aspect of the Earth, may rather resemble that of bright, fresh-fractured rocks, with their usual crystalline lustre, and that this condition may contribute to the appearances in question.

The quantity of light received from Venus, when at the distance = 1.000 from the

* Monthly Notices Astr. Soc., Vol. XX. p. 70.

Earth, and having the phase corresponding to $v' = 111°.2$, according to the foregoing observations, is equal to that of the lamp with the aperture **Z**, at a distance $d' = 41.40$ feet. That received from Jupiter, if we omit the observation on April 2d, for the reason assigned in the notes, with a phase corresponding to $v'' = 169°.1$, is equal to that of the lamp with the same aperture at a distance $d'' = 78.52$ feet. We also have, for the distance from **Z** at which the Moon, similarly phased, is equally bright with the lamp,

$$v = 111°.2 \qquad d = 1.826 \text{ ft.}$$
$$v = 169.1 \qquad d = 0.994$$

Hence we shall have the following results: —

For the Moon, at its mean distance from Earth and Sun, its phase corresponding to . . . $v = 111°.2$
And for Venus at a distance from Earth of 1.000, and from the Sun of 0.7233, its phase corresponding to . . . . $v = 111.2$

(31) $$\frac{\text{Light received from Venus}}{\text{Light received from Moon}} = \frac{d^2}{d'^2} = \frac{1}{514}\,.$$

For the Moon at its mean distance from Earth and Sun, its phase corresponding to . . . $v = 169°.1$
And for Jupiter at a distance from Earth of 4.2028, and from the Sun of 5.2028, its phase corresponding to . . . . $v = 169.1$

(32) $$\frac{\text{Light received from Jupiter}}{\text{Light received from Moon}} = \frac{1}{6240}\,.$$

If the light of Jupiter be increased by the correction of its phase to a complete illumination, or by the formula (30) in the ratio $\frac{1.018}{1.000}$, and that of the Moon in the ratio $\frac{1.050}{1.000}$ in accordance with the curve representing the values of H_0, we shall have,

(33) $$\frac{\text{Jupiter at mean opposition}}{\text{Mean full Moon}} = \frac{1}{6430}\,.$$

Seidel has compared the light of Venus and of Jupiter with particular care, by means of a Steinheil photometer; correcting that of Venus to its epoch of greatest brightness, which he assumes to be when its distance from the Earth is $\varDelta' = 0.53944$ and $v' = 76°\ 13'.5$, he finds,*

$$\text{Log.}\ \frac{\text{Venus at greatest brightness}}{\text{Jupiter at mean opposition}} = 0.674.$$

* Untersuchungen über die Lichtstärke der Planeten Venus, Mars, Jupiter, und Saturn, p. 34.

To reduce our results to the same epoch, we have for the change of phase and distance from the Earth, using Lambert's formula,

$$\text{Log.}\ \frac{\text{Venus at } \Delta' = 0.5394 \quad r' = 0.7233}{\text{Venus at } \Delta' = 1.0000 \quad r' = 0.7233} = 0.139.$$

We have also,

$$\text{Log.}\ \frac{\text{Venus at } \Delta' = 1.0000,\ r' = 0.7233,\ v' = 111^\circ.2}{\text{Jupiter at } \Delta'' = 4.2028,\ r'' = 5.2028,\ v'' = 169^\circ.1} = \text{log.}\ \frac{d''^2}{d'^2} = 0.556,$$

which must be diminished by 0.008, to refer the phase of Jupiter to the opposition value, $v = 180^\circ$; hence,

$$\text{Log.}\ \frac{\text{Venus at greatest brightness}}{\text{Jupiter at mean opposition}} = 0.556 + 0.139 - 0.008 = 0.687;$$

differing from Seidel's by only 0.013. The agreement is the more satisfactory, on account of the dissimilarity of the methods used.

In Herschel's "Outlines of Astronomy"* the mean quantity of light sent to the Earth by the full Moon is stated to exceed that sent by α Centauri in the proportion 27408 to 1. This is the result of eleven comparisons made at the Cape of Good Hope after correction for the amount lost by transmission through the photometer; the high altitude of the Moon makes the correction for atmospheric extinction scarcely sensible. As Herschel has apparently used the formula

$$M_1 = \frac{r_0^2\, \Delta_0^2}{r^2\, \Delta^2}\ \text{sin.}^2\ \frac{1}{2}\, v$$

to reduce the moonlight at the several phases to the mean full Moon, in order to find the above proportion when this reduction is accomplished by means of the formula (29), I have computed the following quantities for the eleven dates of observation: —

Mean value	log.	M_1	$= 9.962$
"	"	H_0	$= 9.769$
"	"	$\frac{r_0^2\, \Delta_0^2}{r^2\, \Delta^2}$	$= 0.026$
"	"	ε	$= 0.012$

where ε represents the correction for extinction. We shall then have

* "Outlines," (817).

$$\text{Log.}\ \frac{\text{Mean full Moon}}{\alpha\ \text{Centauri}} = \log.\ [27408] + 9.962 - 9.769 - 0.026 + 0.012 = 4.617.$$

Hence, if we adopt the expression (29), and the values of H_0 determined from observation, Herschel's result becomes,

$$\frac{\alpha\ \text{Centauri}}{\text{Mean full Moon}} = \frac{1}{41400}.$$

According to Seidel, the logarithm of the ratio between the light of Jupiter at its mean opposition and α Lyræ is,*

$$\text{Log.}\ \frac{\text{Jupiter at mean opposition}}{\alpha\ \text{Lyra}} = 0.916.$$

Herschel's and Seidel's photometric determinations furnish the following numbers: † —

Herschel.		Seidel.	
Log. $\frac{\text{Sirius}}{\alpha\ \text{Centauri}}$	= 0.620	Log. $\frac{\text{Sirius}}{\alpha\ \text{Lyræ}}$	= 0.621
" $\frac{\text{Rigel}}{\alpha\ \text{Centauri}}$	= 9.820	" $\frac{\text{Rigel}}{\alpha\ \text{Lyræ}}$	= 9.989
" $\frac{\text{Spica}}{\alpha\ \text{Centauri}}$	= 9.494	" $\frac{\text{Spica}}{\alpha\ \text{Lyræ}}$	= 9.681
" $\frac{\text{Fomalhaut}}{\alpha\ \text{Centauri}}$	= 9.420	" $\frac{\text{Fomalhaut}}{\alpha\ \text{Lyræ}}$	= 9.526
" $\frac{\alpha\ \text{Aquilæ}}{\alpha\ \text{Centauri}}$	= 9.544	" $\frac{\alpha\ \text{Aquilæ}}{\alpha\ \text{Lyræ}}$	= 9.681

whence we obtain: —

$$\text{Log.}\ \frac{\text{Sirius}}{\alpha\ \text{Lyræ}} \times \frac{\alpha\ \text{Centauri}}{\text{Sirius}} = \log.\ \frac{\alpha\ \text{Centauri}}{\alpha\ \text{Lyræ}} = 0.001$$

$$\text{"}\ \frac{\text{Rigel}}{\alpha\ \text{Lyræ}} \times \frac{\alpha\ \text{Centauri}}{\text{Rigel}} = \text{"} \quad \text{"} \quad = 0.169$$

$$\text{"}\ \frac{\text{Spica}}{\alpha\ \text{Lyræ}} \times \frac{\alpha\ \text{Centauri}}{\text{Spica}} = \text{"} \quad \text{"} \quad = 0.187$$

$$\text{"}\ \frac{\text{Fomalhaut}}{\alpha\ \text{Lyræ}} \times \frac{\alpha\ \text{Centauri}}{\text{Fomalhaut}} = \text{"} \quad \text{"} \quad = 0.106$$

$$\text{"}\ \frac{\alpha\ \text{Aquilæ}}{\alpha\ \text{Lyræ}} \times \frac{\alpha\ \text{Centauri}}{\alpha\ \text{Aquilæ}} = \text{"} \quad \text{"} \quad = 0.137.$$

* Untersuchungen über die Lichtstärke der Planeten Venus, Mars, Jupiter, und Saturn, p. 34.

† Ibid., p. 31.

Taking the mean, we have

$$\text{Log.}\ \frac{\alpha\ \text{Centauri}}{\alpha\ \text{Lyræ}} = 0.120.$$

Hence, from Herschel's observations of the Moon, according to the above reduction,

$$\frac{\text{Jupiter at mean opposition}}{\text{Mean full Moon}} = \frac{\alpha\ \text{Centauri}}{\text{Moon}} \times \frac{\text{Jupiter}}{\alpha\ \text{Lyræ}} \times \frac{\alpha\ \text{Lyræ}}{\alpha\ \text{Centauri}} = \frac{1}{6620}.$$

Considering the number of intermediate steps required in effecting the comparison of the original data, this confirmation of the value before given in (33), viz.:

$$\frac{\text{Jupiter at mean opposition}}{\text{Mean full Moon}} = \frac{1}{6430},$$

is entirely satisfactory.

If we make in (13),

$$\frac{\rho}{\Delta} = \sin.\ 15' \ 34''.67 = \text{sin. Moon's semidiameter at its mean distance from the Earth,}$$

$$\frac{\rho'}{\Delta'} = \sin.\ 0 \ \ 8.67 = \text{sin. Venus's semidiameter at the distance 1.0000 " "}$$

$$\frac{\rho''}{\Delta''} = \sin.\ 0 \ 22.77 = \text{sin. Jupiter's " " 4.2028 " "}$$

$$\frac{R}{r} = \frac{1.0000}{1.0000}, \ \text{for the Moon,}$$

$$\frac{R}{r'} = \frac{1.0000}{0.7233}, \ \text{for Venus,}$$

$$\frac{R}{r''} = \frac{1.0000}{5.2028}, \ \text{for Jupiter,}$$

the amount of light received at the Earth, compared with sunlight, will be,

$$(34)\quad \left\{ \begin{aligned} \frac{di'}{dL} &= \frac{\Theta\mu}{194810} = \frac{\text{Light of Moon}}{\text{Light of Sun}}, \\ \text{"} &= \frac{\Theta'\mu'}{1\,184\,400\,000} = \frac{\text{Light of Venus}}{\text{Light of Sun}}, \\ \text{"} &= \frac{\Theta''\mu''}{8\,884\,600\,000} = \frac{\text{Light of Jupiter}}{\text{Light of Sun}}. \end{aligned} \right.$$

Hence at the Earth,

$$(35)\quad \begin{cases} \dfrac{\text{Light of Venus}}{\text{Light of Moon}} = \dfrac{1}{6080}\,\dfrac{\Theta'}{\Theta}\,\dfrac{\mu'}{\mu}, \\[2ex] \dfrac{\text{Light of Jupiter}}{\text{Light of Moon}} = \dfrac{1}{45610}\,\dfrac{\Theta''}{\Theta}\,\dfrac{\mu''}{\mu}. \end{cases}$$

But according to observation, we have in (31) and (32),

$$\frac{\text{Light of Venus at the phase } v' = 111^\circ.2}{\text{Light of Moon at the phase } v = 111^\circ.2} = \frac{1}{514},$$

$$\frac{\text{Light of Jupiter at the phase } v'' = 169^\circ.1}{\text{Light of Moon at the phase } v = 169^\circ.1} = \frac{1}{6240};$$

and from (35),

$$(36)\quad \begin{cases} \dfrac{\mu}{\mu'} = \dfrac{1}{11.83}\,\dfrac{\Theta' \text{ for } v' = 111^\circ.2}{\Theta \text{ for } v = 111^\circ.2} & \text{Venus and Moon,} \\[2ex] \dfrac{\mu}{\mu''} = \dfrac{1}{7.31}\,\dfrac{\Theta'' \text{ for } v'' = 160^\circ.1}{\Theta \text{ for } v = 169^\circ.1} & \text{Jupiter and Moon.} \end{cases}$$

If we suppose the surfaces of these bodies to absorb different proportions of the whole incident sunlight, while the light reflected by each is dispersed symmetrically in different directions, we should have,

$$(37)\quad \begin{matrix} \Theta' = \Theta & \text{when} & v' = v, \\ \Theta'' = \Theta & \text{“} & v'' = v. \end{matrix}$$

This would apply for Lambert's or Euler's formula, or for any other of a general nature, when the special constitution of each reflecting body is not taken into account. The substitution of

$$\frac{\Theta'}{\Theta} = 1, \qquad \frac{\Theta''}{\Theta} = 1,$$

in (36), would thus give,

$$(38)\quad \begin{matrix} \dfrac{\mu}{\mu'} = \dfrac{1}{11.83} & \text{Venus and Moon,} & v = 111^\circ.2, \\[2ex] \dfrac{\mu}{\mu''} = \dfrac{1}{7.31} & \text{Jupiter “} & v = 169^\circ.1. \end{matrix}$$

Owing to its situation in the solar system, Venus can afford reliable photometric observations only when near its position of greatest brightness, being then at a little less than the half-Moon phase, while that of Jupiter is always nearly full. If, however, we suppose the light of the two planets to be distributed agreeably to Lambert's

theory, and if we reduce the phases of the Moon to full, by means of the proportions derived from observation, and given on p. 256, we have,

$$\text{Log.}\ \frac{\Theta \text{ for } v = 180°.0}{\Theta \text{ for } v = 111°.2} = 0.548, \qquad \text{Log.}\ \frac{\Theta \text{ for } v = 180°.0}{\Theta \text{ for } v = 169°.1} = 0.021,$$

$$\text{Log.}\ \frac{\Theta' \text{ for } v' = 180°.0}{\Theta' \text{ for } v' = 111°.2} = 0.284, \qquad \text{Log.}\ \frac{\Theta'' \text{ for } v'' = 180°.0}{\Theta'' \text{ for } v'' = 169°.1} = 0.008\,;$$

and thence,

$$(39) \quad \begin{aligned} \frac{\mu}{\mu'} &= \frac{1}{6.441}\,\frac{\Theta_0'}{\Theta_0} \quad \text{Venus and Moon, full phase,} \\ \frac{\mu}{\mu''} &= \frac{1}{7.094}\,\frac{\Theta_0''}{\Theta_0} \quad \text{Jupiter and Moon,} \quad \text{"} \end{aligned}$$

where Θ_0, Θ_0', Θ_0'' represent the values of Θ for each body when full phased.

That Venus and Jupiter very much exceed the Moon in their capacity for reflecting light, is evident from the above. It would seem, moreover, that in this respect Venus nearly resembles Jupiter, provided that Lambert's reduction for phase is applicable; it is, perhaps, questionable whether this can be admitted.

Seidel* has collected and discussed with great care a very large number of photometric comparisons of Venus and Jupiter, and has deduced for ratio of their respective *albedos*,

$$\frac{\mu'}{\mu''} = 0.958.$$

Our results, if we adopt the numbers in (39), give

$$\frac{\mu'}{\mu''} = 0.908.$$

Both depend on Lambert's phase-correction; but since they have been obtained at nearly the same average relative position of the Earth, Sun, and planets, the agreement proves little, as regards the question of the reliability of the phase-correction. The uncertainty, however, does not admit of remedy, for although Venus, like the Moon, presents itself successively in every phase, it is only when at a considerable angular distance from the Sun that it can be well observed. Its low altitude, and the strong twilight surrounding it, throw a doubt over all evening or morning observations made in the neighborhood of either conjunction with the Sun; but the fact of its being visible

* Untersuchungen über die Lichtstärke der Planeten Venus, Mars, Jupiter, und Saturn, p. 52.

on the very day of inferior conjunction, as a narrow crescent, distant but 5° or 6°, or even less, from the Sun, notwithstanding the intense illumination of the sky, is evidence of a notable deviation from Lambert's theory; for in this situation, not only is the illuminated area exceedingly small, but its light, according to that theory, will be intrinsically fainter than in other positions. The reason of this discrepancy is plainly because the theory does not take into account the light *regularly* reflected, which is considerable, even for opaque bodies, when the angle of incidence and of reflection is small. If the surface of Venus were polished, it would be, when distant $7\frac{1}{4}°$ from its inferior conjunction with the Sun, nearly six times brighter than at its greatest elongation; on the other hand, if opaque, by Lambert's formula, it would be above eighty times fainter, which is altogether at variance with observation.* It may be inferred, as a consequence of this deviation from the theory, supposed to be due to a tendency to a regular reflection, that the albedo of Venus, computed from observations about the time of greatest brilliancy, and especially as it approached its inferior conjunction, will be too large, that is, it will exceed its average value in other positions.

For the purpose of finding the value of μ for the Moon, if we suppose an element $d\,e$ presented perpendicularly to its rays, the quantity of moonlight incident upon it will be, as in (24),

$$d\,i' = \frac{\Theta\,\mu\,I}{16\,\pi}\,\frac{\rho^2}{r^2}\,\frac{d\,e}{\Delta^2}.$$

The whole quantity incident upon the concave surface of a sphere, having a radius Δ, and circumscribed about the Moon as a centre, will be represented by

$$\int d\,i' = \frac{\mu\,I}{16\,\pi}\,\frac{\rho^2}{r^2\,\Delta^2}\int \Theta\,d\,e.$$

But if the Moon everywhere shone with its full phase, the total light would be

$$\int d\,i_0' = \frac{\mu\,I}{16\,\pi}\,\frac{\rho^2}{r^2\,\Delta^2}\int \Theta_0\,d\,e.$$

Since $H_0 = \frac{\Theta}{\Theta_0}$ and $\int \Theta_0\,d\,e = 4\,\pi\,\Delta^2\,\Theta_0$, we have,

(40) $$i' = \frac{i_0'}{4\,\pi\,\Delta^2}\int H_0\,d\,e.$$

By means of the table of values of log. H_0, given on page 256, we may compute the

* During the total eclipse of the Sun, July 18, 1861, Venus, being then at its inferior conjunction, was seen by Bruhns with the naked eye, and was considerably brighter than Jupiter. Astr. Nach. 1292, p. 312.

value of $\int H_0\, d\,e$, extending the integration so as to include the whole surface of the circumscribed sphere of which $d\,e$ is an element; we then have,

$$\int H_0\, d\,e = \int_0^\pi 2\,\pi\,\Delta^2\,H_0\,\text{sin.}\,v\,d\,v = 0.463 \times 2\,\pi\,\Delta^2,$$

so that from (40)

(41) $$i' = 0.232\ i_0';$$

from which it appears that the whole amount of light reflected from the Moon is about one fourth as much as if it shone in all directions with the full phase.

The quantity of sunlight incident on the Moon is, by (10),

$$i = \frac{I}{4}\,\frac{\rho^2}{r^2};$$

and from (41),

(42) $$\frac{i'}{i} = 0.232 \times 4\,\frac{i_0'}{I}\,\frac{r^2}{\rho^2}.$$

If the light of the full Moon, incident perpendicularly at the Earth, upon an element of surface $d\,e$ at the distance Δ from it, is to the light of the Sun upon the same element at the distance r, as $1 : S$, we shall have,

(43) $$\frac{i_0'}{I} = \frac{1}{S}\,\frac{\Delta^2}{r^2},$$

and by substitution in (42),

(44) $$\frac{i'}{i} = 0.928\,\frac{\Delta^2}{\rho^2}\,\frac{1}{S},$$

in which we may make

$$\frac{\Delta^2}{\rho^2} = \left(\frac{1}{\text{sin. Moon's semidiameter}}\right)^2 = \frac{1}{\text{sin.}^2\,934''.67} = 48700;$$

and (44) becomes,

(45) $$\frac{\text{Amount of light reflected from the Moon}}{\text{Amount of light incident upon the Moon}} = \frac{i'}{i} = \frac{45193}{S}.$$

Hence, by (4), the albedo of the Moon will be

(46) $$\mu = \frac{45193}{S}.$$

It is a matter of much difficulty to ascertain S from observation, on account of the strong contrast between the intensity of sunlight and moonlight, and the want of a reliable constant light of the proper color, to which both may be referred. The observations of Bouguer and Wollaston are notably inconsistent; the mean between them

makes the Sun about *five hundred and fifty thousand* times brighter than the full Moon,* in which case

$$\mu = \frac{1}{11}.$$

If the whole quantity of sunlight reflected by the Moon, which is $\mu\, i$, were dispersed from it as if it were a polished sphere, — that is, equally in all directions, — the amount of moonlight incident upon $d\, e$ would be

$$\frac{\mu i\ de}{4\pi\ \Delta^2} = \frac{i'\ de}{4\pi\ \Delta^2};$$

but the actual amount incident upon $d\, e$ is

(47) $$\frac{H_0\ i_0'\ de}{4\pi\ \Delta^2},$$

and therefore, since, from the definition on p. 233, Θ is the ratio of these two quantities,

(48) $$\Theta = H_0 \frac{i_0'}{i'}.$$

Hence, using from (41) $\frac{i_0'}{i'} = \frac{1}{0.232}$ for the Moon,

(49) $$\begin{cases} \Theta = 4.31\ H_0 & \text{for the Moon,} \\ \Theta' = 2.67\ H_0' & \text{for Venus,} \\ \Theta'' = 2.67\ H_0'' & \text{for Jupiter,} \end{cases}$$

and for the two latter assuming, as in (15),

(50) $$\begin{cases} H_0' = H_0'' = \dfrac{\sin. v - v \cos. v}{\pi}, \\ \Theta' = \Theta'' = \dfrac{8}{3}\ \dfrac{\sin. v - v \cos. v}{\pi}, \end{cases}$$

we shall have, from (39),

(51) $$\begin{cases} \dfrac{\Theta_0'}{\Theta_0} = \dfrac{1}{1.616}, & \dfrac{\Theta_0''}{\Theta_0} = \dfrac{1}{1.616}, \\ \dfrac{\mu}{\mu'} = \dfrac{1}{10.41}, & \dfrac{\mu}{\mu''} = \dfrac{1}{11.47}, \end{cases}$$

which are, perhaps, the most reliable values which the data in our possession will furnish.

* For a new determination of this ratio, giving $S = 470980$ and $\mu = \frac{1}{10.4}$, the reader is referred to a memoir in a subsequent part of this volume.

If the value $\mu = \frac{1}{11}$ be adopted, the albedos of Venus and Jupiter will be nearly $= 1$, which can scarcely be true, since in this case the planets must reflect the whole light incident upon them, while the whitest substances known on the Earth reflect less than one half of the incident light.* As regards Venus, we have mentioned reasons to show that a tendency to a *regular* reflection of sunlight from its surface may possibly explain its excess of brightness; but the case is quite otherwise with Jupiter, for here the planet is presented nearly at full phase, and in this position the quantity of light reflected from an opaque globe should be at least twice as great as from one of equal albedo reflecting regularly. Moreover, it is quite certain that the disc of Jupiter presents gradations of brightness from its centre to the circumference, conforming sufficiently well with Lambert's theory, and this circumstance gives additional confidence in the use made of his formula in obtaining the result before us.

As the foregoing calculations cannot be readily followed through their details, and on this account may be open to some doubt as to their correctness, the following experiments of a different kind, though less precise, will be useful in confirming the results which have been obtained.

The light from a small area of the Moon was compared with that of Jupiter by receiving the pencil from the focus of the object-glass of the 23-foot refractor upon a screen, or upon the silvered glass globe B_2, described on p. 247, equalizing each in turn with the image of the light of a lamp provided with a diaphragm, and placed at a suitable distance. The relative brightness of the images reflected from the globe was easily varied by moving it towards or away from the focus of the telescope. The minutes of some other comparisons, principally relating to the absorption of the light of Jupiter by colored glass screens, are also added.

1860, March 2d. Clear. Moon $4\frac{1}{2}$ days before full ($v = 119°$) compared with Jupiter. Both near the meridian and at the same altitude. A brass diaphragm plate having a hole with an aperture of $0^{in}.0425$, admitting a pencil of light $32''.47$ in diameter, was placed in the focus of the object-glass of the 23-foot refractor, and the telescope, with its aperture of $14^{in}.94$, was directed alternately upon Jupiter and the Moon; the image of a disc of each object subtending the above-named angle was received, without the intervention of any eye-piece, upon a screen of black book-binder's muslin fastened to a square of pasteboard, and washed with a thin shade of indigo to destroy the gloss, and give a dead blue-black surface. The screen was moved from the focus until the light of the image projected upon it could just be discerned; its distance from the focus was then noted, its position being fixed by three observers.

* Beer, Grundriss des Phot. Cal., p. 70.

The telescope was kept in motion by the driving clock during the intervals of observation.

		ft.
Jupiter,	Screen to focus,	3.0
"	" "	3.5

Telescope directed to the Moon and set so that the focus-aperture included a region south of the *Mare Fecunditatis*, thought to be as bright as the average of the brighter parts of the Moon.

		ft.
S. of *Mare Fecunditatis*,	Screen to focus,	3.83
Brighter region,	" "	4.33
Dark — *Mare Crisium*,	" "	3.33

Near *Mare Crisium*, a little north of it, considered to be as bright as any part of the Moon.

		ft.
N. of *Mare Crisium*,	Screen to focus,	4.50
Jupiter,	" "	3.67
"	" "	3.67

The surrounding illumination was the same for both objects in the above experiments.

Subsequently the same diaphragm was placed in the focus of an eye-piece having a power of 206, and the planet and a disc of the Moon of equal angular diameter were compared by the eye alternately. It was evident that the color of the two was nearly similar, and that, while the intensity of the Moon's most brightly illuminated region exceeded that of the planet, the brighter *Seas* were about equal to it, and some were darker.

The brighter parts of the Moon selected for the above comparisons were near the selenographic meridian passing through the Sun, and were therefore illuminated at the maximum angle of incidence.

1860, March 15th. 8^h to 10^h, m. s. t. Fine clear sky. Cloudless and calm.

Examined Jupiter at a high altitude near the meridian, with screen glasses of different tints interposed between the eye and the eye-piece of the 23-foot refractor, full aperture. Power, 206. Focus aperture as above, $32''.47$. It was proposed at some future time to employ the same screens upon the Sun and Moon.

After keeping the eye in a dark room for several minutes, the light of the planet could be discerned with ease through screen-glasses *D* and *E*, both deep red; certainly, but not always without some difficulty, through $A + M$, *A* a steel blue, dense, and *M* a thin glass, tint of Madeira wine. *B* and *C*, both bluish, admitted glimpses, but not with entire certainty.

1860, March 16th. 7^h 30^m to 8^h 30^m, Sid. time. Fine clear sky. Eye-piece, focus aperture, &c., as on 15th.

Jupiter near the meridian, viewed with colored screens, *A*, *B*, and *C*, of different densities, but same tint, bluish. *E*, dense, full red. *F*, yellow, with tinge of green, dense. *G*, dense blue. *K*, yellowish red or orange, thin. *L*, indigo, thin.

Jupiter, near meridian, seen plainly with *A*; just discerned with entire certainty through $A + K$ and $A + L$. Easily with *F* and *G*, though they would not bear much increase of density. *E* comes nearest to cutting off the whole light, but it is still plainly seen, and the red tinge is evident, which would not be the case if the light were of the last degree of faintness. The centre of the planet was placed, as usual, at the centre of the focus aperture, and the telescope kept in motion by the driving clock. The word "Astronomy" on the title-page of Herschel's "Outlines" could be read by the light of Sirius near the focus.

1860, March 19th. $7^h\ 9^m$, Sid. time. Not perfectly clear. Same adjustment as on previous nights. Re-examined light of Jupiter with screen $A + K$. Seen distinctly, though not without difficulty. With *E*, a decided red tint is distinguished. Observations repeated at $9^h\ 30^m$, Sid. time.

1860, March 23d. 9^h, m. s. t. Perfectly clear. Adjustments as usual. Jupiter examined with screens $A + K$ and *E*, for comparison with experiments elsewhere narrated.

1860, March 24th. $7^h\ 15^m$ to $7^h\ 40^m$, Sid time. Moon two days old, near Venus. Aperture $14^{in}.94$.

Moon seen with difficulty, though certainly with *E*, but not with $A + K$, taking the average of the brightest *fifth part* of the illuminated surface.

Reduced the aperture to $2^{in}.5$, and set upon Venus, at $7^h\ 40^m$, Sid. time. The planet was not visible at all with *E*. Perhaps discerned with $A + K$. Two hours later, Jupiter, with full aperture, showed a strong red with *E*.

The eye-piece having been removed, the light of Jupiter transmitted by the object-glass was compared with the lamp *S*, diaphragm **Z**, by means of the photometer as described on p. 247.

$9^h\ 41^m$ Sid. time.	Centre of bulb to focus,	ft. 5	in. 0.7	To lamp,	ft. 22 in. 1.0
	" "	4	1.0	"	22 1.0
	" "	4	2.0	"	22 4.8
	" "	4	4.7	"	22 4.8
	" "	4	4.7	"	23 1.0
10 9 "	" "	4	11.7	"	26 11.0

Applied a new diaphragm to the lamp. Aperture 0^in^.021.

	Centre of bulb to focus,	ft. in. 8 7.9	To lamp, ft. in. 22 8.0
h m 10 39	" "	8 11.0	" 23 0.0

1860, March 27th. Adjustments and lamp as on March 24th.

h m 9 59	Sid. time.	Centre of bulb to focus,	ft. 3.70	To lamp,	ft. 25.80
10 3	"	" "	3.60	"	25.80

1860, March 30th. A thin, red haze in the sky. Moon $8\frac{1}{2}$ days old ($v = 99°$) and distant but a few degrees from Jupiter. 23-foot refractor, with aperture 14^in^.94 set on the planet; eye-piece removed, and the focal image (without diaphragm), compared with lamp *S*, aperture **Z**, by means of the photometer bulb.

h m 8 41	Sid. time.	Jupiter.	Centre of bulb to focus,	ft. 2.75	To lamp,	ft. 19.5
8 45	"	"	" "	2.45	"	19.5
8 48	"	"	" "	2.53	"	19.5
8 54	"	"	" "	2.60	"	19.5

Focus diaphragm applied, admitting pencil from Moon, 32″.47 diameter.

h m 9 4	Sid. time.	Bright part of Moon, south of *Mare Crisium.*	Bulb to focus,	ft. 2.90	To lamp,	ft. 18.0
9 12	"	Centre of southern half of *Mare Crisium.* Sun's alt. 75°.	"	2.42	"	17.5
9 16	"	Brightest part, where Sun is vertical.	"	2.95	"	16.2
9 19	"	Dark part of *Mare Tranquillitatis,* 3′ or 4′ from *Mare Crisium* in a line towards the centre of Moon. Sun's alt. 50°.	"	2.43	"	18.0
9 26	"	Brightest part as it appears to the naked eye, north of *Mare Crisium.*	"	2.70	"	14.2
9 34	"	Near centre, 1′ from dark edge.	"	1.10	"	20.3
9 39	"	A smooth area 30″ from dark edge, not specially brighter than other parts similarly situated.	"	0.95	"	20.3

The haze in the air probably obstructed a sensible amount of light, but as the objects were near each other, and at a high altitude, it is likely that the relative quantities of light will be correctly given.

As the focus diaphragm was not used on this occasion for the planet, it was thought advisable to try whether the diffused illumination of the Earth's atmosphere by moonlight was sufficient to affect the experiments, but no image from the sky alone could be

distinguished on the bulb, when placed at the distance of two or three feet from the focus.

Removed focus diaphragm and returned to Jupiter without altering lamp.

h m				ft.		ft.
9 46	Sid. time.	Jupiter.	Bulb to focus,	2.60	To lamp,	21.70
9 49	"	"	"	2.90	"	21.70
9 55	"	"	"	1.24	"	10.74
10 0	"	"	"	1.50	"	10.96
10 4	"	"	"	1.45	"	11.00

1860, April 2d. Quite clear. No clouds seen through the evening. Moon $2\frac{3}{4}$ days from full ($v = 141°$). For Jupiter, the focal image, without diaphragm, was used.

h m									ft.
9 17	Sid. time.	Jupiter.	Bulb to focus,	3.75	To lamp	*I.*	Diaphragm	Z.	20.60
9 29	"	"	"	5.25	"	*I.*	"	M.	23.44
9 34	"	"	"	5.95	"	*I.*	"	M.	23.30
9 42	"	"	"	5.80	"	*S.*	"	M.	23.90
9 48	"	"	"	6.05	"	*S.*	"	M.	24.27
10 9	"	"	"	6.95	"	*R.*	"	M.	24.60
10 15	"	"	"	5.80	"	*R.*	"	M.	20.60
10 29	"	"	"	5.10	"	*W.*	"	M.	21.30
10 33	"	"	"	5.55	"	*W.*	"	M.	23.60

Set upon Moon. Focus diaphragm 32″.47.

h m				ft.					ft.
10 47	Sid. time.	Moon, brightest part in southern hemisphere, where Sun's alt. = 60°.	Bulb to focus,	5.80	To lamp	*W.*	Diaphragm	M.	12.70
10 54	"	Centre of *Mare Tranquillitatis*, in a line between the Crater *Maskelyne* and the *Mare Crisium*. Sun's alt. 85°. This is the darkest part of the Moon, upon which the Sun is shining at a high altitude.	"	6.20	"	*W.*	"	M.	19.70
11 5	"	*Mare Crisium*. Sun's alt. 75°. It is brighter than *Mare Tranquillitatis*.	"	6.20	"	*W.*	"	M.	17.20

The first series, March 2d, gives the relative quantity of light transmitted to the Earth from a circular area of Jupiter, 32″.47 in diameter, compared with the light from areas subtending the same angle, taken from different parts of the Moon. This proportion for the brighter regions of the Moon, on which the Sun is shining at a high altitude, is

$$\left(\frac{3.5}{4.5}\right)^2 = \frac{49}{81}.$$

At the same date, the intensity of sunlight at Jupiter and at the Moon was as 1 : 27.9. Hence,

$$\frac{49}{81} \times \frac{27.9}{1} = 16.9$$

would be the proportion of the albedos of the two surfaces, provided that they received and reflected the incident light under similar conditions. This, however, is not the case. The area of the Moon, included by the aperture in the focus diaphragm, is so small that it may be considered as being illuminated sensibly at the same angle of incidence throughout. If we take 60° as the mean value of this angle for the parts of the Moon compared and regarded at this date as noticeably brighter than the rest, we must diminish the above proportion in the ratio sin. 60° : 1, to represent the effect of the increased quantity of sunlight which would reach the same surface at perpendicular incidence. On the other hand, the aperture admits nearly the whole of the light of Jupiter, and the sunlight, on account of the curvature of the surface of the planet, being received at very different angles, it should present a gradation in the intensity of its light, proceeding from the centre towards the circumference. It is difficult, or rather quite impossible, to define precisely the rate of this decrease; but, from facts which will be elsewhere stated, it is certain that its light near the margin is much fainter than towards the centre. According to the best estimates which I have been able to make, the coefficient to be applied in order to reduce the mean brightness of a central disc of Jupiter, 32″.47 in diameter, to the mean brightness of the whole disc on March 2d, is $\frac{1}{1.32}$. Again, to reduce the mean brightness of the illuminated hemisphere to that of the central element presented at right angles to the direction of illumination, we must apply the coefficient $\frac{1}{0.70} = 1.43$. These numbers do not materially differ from those which would result from supposing, as Lambert has done, that the intensity varies as the sine of the angle of incidence of the sunlight.

Applying the above, we should have, from the observation of March 2d, a value of $\frac{\mu''}{\mu}$ which would represent the relative albedo of Jupiter compared with the Moon's brighter regions, if both bodies are supposed to reflect light conformably with the same law of dispersive reflection, which, according to Bouguer and Lambert, holds approximately for the generality of opaque bodies; viz. that the quantity of light emitted towards a given point from each element is proportional to the solid angle subtended at the point by the element. However, we have seen, in the case of the Moon, that it has the property of returning an undue amount of light towards the Earth at the time of full Moon, which would cause the other phases to appear disproportionately faint.

This will explain the reason why the relative albedo of Jupiter, obtained after the above corrections have been applied, viz.

$$\left(\frac{3.5}{4.5}\right)^2 \frac{27.9}{1} \frac{1.43}{1.32} \text{ sin. } 60^\circ = 15.8,$$

the Moon being 61° from opposition ($v = 119°$), is larger than that given in (51). The latter is certainly to be preferred, because it is a result depending on the average of the whole illuminated surface of the Moon, seen under various phases, while the former relates to but one or two isolated points of a single phase.

Perhaps the most probable correction which we can adopt, to refer the partial and incomplete result derived from any single phase to the more general condition, is to apply the coefficient $\frac{H_0}{L_0} = \frac{1}{1.72}$, taken from the table on page 257, L_0 being the value of H_0 according to Lambert's formula. We then have,

$$\left(\frac{3.5}{4.5}\right)^2 \cdot \frac{27.9}{1} \cdot \frac{1.43}{1.32} \cdot \frac{H_0}{L_0} \text{ sin. } 60 = 9.2,$$

or

$$\frac{\mu}{\mu''} = \frac{1}{9.0} \text{ for the brightest parts of the Moon;}$$

and in the same way,

$$\frac{\mu}{\mu''} = \frac{1}{17} \text{ for the darker regions having the Sun at high altitude.}$$

The corrections due to the phase of Jupiter and to the difference of extinction are not appreciable. Proceeding in a similar manner, we may reduce the observations on other dates, noticing the changes required when the light from the whole disc of the planet has been admitted.

On March 30th, we have, for the logarithm of the ratio of the brightness of the focal image of Jupiter compared with the lamp, taking the mean of the observations,

$$\text{Log.} \frac{\text{Jupiter}}{\text{Lamp}} = 8.227,$$

and for the portion of the bright parts of the Moon admitted by the aperture in the focus diaphragm,

$$\text{Log.} \frac{\text{Moon}}{\text{Lamp}} = 8.540.$$

The coefficients for the several corrections will be

$$\frac{\text{Brightness of central element of Jupiter}}{\text{Average brightness of Jupiter}} = 1.43,$$

$$\left(\frac{\text{Diameter of aperture} = 32''.47}{\text{Diameter of Jupiter}}\right)^2 = \frac{1}{1.36},$$

$$\frac{r''^2}{R^2} = 27.6,$$

$$v = 99^\circ \quad \log. \frac{H_0}{L_0} = 9.674,$$

from which we shall find

$$\frac{\mu}{\mu''} = \frac{1}{6} \quad \text{Brightest parts of the Moon,}$$

and similarly,

$$\frac{\mu}{\mu''} = \frac{1}{12} \quad \textit{Mare Crisium,}$$

$$\frac{\mu}{\mu''} = \frac{1}{10} \quad \textit{Mare Tranquillitatis.}$$

April 2d. The comparisons with lamp *W*, diaphragm **M**, give,

$$\text{Log.} \frac{\text{Jupiter}}{\text{Lamp}} = 8.751,$$

$$\text{Log.} \frac{\text{Moon}}{\text{Lamp}} = 9.319,$$

for the brightest part of the Moon;

$$\frac{\text{Brightness of central element of Jupiter}}{\text{Average brightness of Jupiter}} = 1.43,$$

$$\left(\frac{\text{Diameter of aperture} = 32''.47}{\text{Diameter of Jupiter}}\right)^2 = \frac{1}{1.35},$$

$$\text{Correction for relative extinction} = 1.04,$$

$$\frac{R^2}{r''^2} = 27.6,$$

$$v = 141^\circ \quad \log. \frac{H_0}{L_0} = 9.871;$$

and thence,

$$\frac{\mu}{\mu''} = \frac{1}{5} \quad \text{Brightest part of Moon.}$$

The other comparisons give

$$\frac{\mu}{\mu''} = \frac{1}{12} \quad \textit{Mare Tranquillitatis,}$$

$$\frac{\mu}{\mu''} = \frac{1}{9} \quad \textit{Mare Crisium;}$$

or if the reductions are made by Lambert's theory,

$$\frac{\mu}{\mu''} = \frac{1}{7} \quad \text{Brightest part of Moon,}$$

$$\frac{\mu}{\mu''} = \frac{1}{17} \quad \textit{Mare Tranquillitatis,}$$

$$\frac{\mu}{\mu''} = \frac{1}{13} \quad \textit{Mare Crisium.}$$

Neither of the two methods adopted in these reductions can claim much confidence, since we know so little of the nature of the reflecting surfaces; however, the fact of the greatly superior albedo of Jupiter is satisfactorily established, each substantially confirming the result first obtained.

If now we return to the photographic experiments, we find for the ratio of the chemical albedo, so to speak, of the two bodies,

$$\frac{\text{Average chemical intensity of Full Moon}}{\text{Average chemical intensity of Jupiter}} = \frac{1}{9}.$$

If we assume a similar distribution of the chemical and optical rays at the different phases, we may apply the coefficient

$$\frac{\Theta_0''}{\Theta_0} = \frac{1}{1.616},$$

as in (51). We then have

$$\frac{\text{Chemical albedo of Moon}}{\text{Chemical albedo of Jupiter}} = \frac{1}{14},$$

agreeing quite as well as could have been anticipated with (51), viz.:

$$\frac{\text{Optical albedo of Moon}}{\text{Optical albedo of Jupiter}} = \frac{1}{11.47}.$$

The most satisfactory estimate of the degree of whiteness of the Moon's surface, compared with objects on the Earth, is contained in the following statement by Sir John Herschel.

"The actual illumination of the lunar surface is not much superior to that of weathered sandstone rock in full sunshine. I have frequently compared the Moon, setting behind the gray, perpendicular façade of the Table Mountain, illuminated by the Sun just risen in the opposite quarter of the horizon, when it has scarcely been distinguishable in brightness from the rock in contact with it. The Sun and Moon being nearly at equal altitudes and the atmosphere perfectly free from cloud or vapor, its effect is alike on both luminaries."*

These observations acquire more weight from the circumstance that the light from a distant and elevated object, like the top of a mountain viewed in the same range with the Moon, is modified by aerial perspective, so that the two have a similar quality of tone, and may be compared, in regard to their relative brightness, with greater confidence than if one were close at hand, and the other distant. This will be best recognized in attempting, in the daytime, to compare the light of an opaque object, held not far from the eye, with the Moon; the latter, owing to the intervening atmosphere, has a shadowy, unsubstantial look, which makes it very difficult to estimate the intensity of its light. In Herschel's experiment, the mountain summit (if the observation was made from Feldhausen, as was probably the case) must have been some miles distant, and high enough to rise well into a pure atmosphere. The Moon at the time was a day or two past the full.

We may infer, then, that there is no marked deficiency in the Moon, contrasted with the Earth, as to its capacity for reflection, since the "gray weathered sandstone" of the top of Table Mountain would not, in this respect, be an inadequate representative of the Earth's general surface.

The following experiments relate to the determination of the relative albedo of Jupiter, and different objects on the Earth.

1860, March 17th. $0^h\ 30^m$, m. s. t. A thin haze in the sky. Observations were made in the clear intervals. The 23-foot refractor, aperture of object-glass reduced to 9 inches, was pointed at the side of a brick building, presented at right angles and distant $2\frac{1}{2}$ miles, on which the Sun was shining at an angle of incidence $= 50°$ (the angle which a line directed to the Sun makes with the plane of the face of the wall). With the same power and focal diaphragm employed in viewing Jupiter, March 15th, 16th, 19th, &c., the light reflected from the brick wall could just be discerned through the screen-glasses $A + K$, the eye having been protected from daylight for about half an hour.

After applying corrections similar to those employed in reducing the comparisons between Jupiter and the Moon, and allowing for the difference of aperture of the object-glass, we find,

* Outlines of Astronomy, (417), note, p. 272.

$$\frac{\text{Albedo of brick-work}}{\text{Albedo of Jupiter, central element}} = \frac{1}{8}.$$

This is not entitled to much confidence for several reasons, but especially on account of the difference in color. The side of the house was also strongly illuminated by light reflected from surrounding objects, by which its brightness must have been considerably increased; the illumination of the atmosphere intervening would also have a similar tendency. Hence it seems probable that the denominator of the fraction expressing the relative albedos is too small; the experiment taken in connection with (51) will therefore be in keeping with previous results.

A distant hill-side of withered grass was not sensibly brighter than the bricks; a tract of woodland, without leaves, was darker. The brick was supposed to reflect about one fifth as much light as an equal surface of pure white paper.

1860, March 19. $0^h\ 30^m$ to $1^h\ 0^m$, m. s. t. Clear, with haze near horizon. The same adjustments and screen-glasses as were used in viewing Jupiter.

Repeated comparison with brick wall as on 17th. The image seemed slightly more intense than that of Jupiter.

The side of a wooden house, painted white, and by subsequent trial found to be barely distinguishable from the purest white paper, gave,

$$\frac{\text{Albedo of side of white house}}{\text{Albedo of Jupiter, central element}} = \frac{1}{2}.$$

A variety of objects in the landscape, — fields, bare or covered with withered grass, trees, rocks, fences, &c., — in the azimuth opposite to the Sun's, and again nearly in the same azimuth with it, gave,

$$\frac{\text{Albedo of landscape}}{\text{Albedo of Jupiter}} = \frac{1}{8}.$$

1860, March 23d. 1^h m. s. t. Sky perfectly clear, — between cumuli. Adjustments, eye-piece, &c., as usual, but the aperture of the object-glass was reduced until the objects viewed through the colored screens were judged to have less brightness than Jupiter. From five trials, after applying the proper corrections, I find,

$$\frac{\text{Albedo of side of white house}}{\text{Albedo of Jupiter, central element}} = \frac{1}{2.1}.$$

A sheet of white paper placed against the side of the house was found to be a good match in point of brightness. A disc of chalk, ground flat and painted with "Flake white," was, however, sensibly whiter.

As this was considered the most satisfactory of the trials made with the colored screens, the corrections which have been applied in the reductions are here added.

The intensity of the light of the two objects admitted by the focus diaphragm of $0^{in}.0425$ diameter, was judged to be the same when the ratio of the exposed areas of the object-glass was

$$\frac{\text{Area of object-glass for house}}{\text{Area of object-glass for Jupiter}} = 0.090.$$

The actual illumination of the side of the house by the direct light of the Sun at an incidence angle of 30°, added to the light received by reflection from surrounding objects, was estimated, experimentally, to be to the illumination which it would receive directly from the Sun, at perpendicular incidence, as 4 to 3; and the coefficient $\frac{3}{4}$ has been accordingly applied to the ratio of the areas of the object-glass, so as to refer the comparisons to the maximum illumination of the object by direct sunlight.

For distinct vision of the house, the eye-piece, with the focus diaphragm, was moved $4^{in}.4$ from the object-glass, contracting the angle subtended by the diaphragm at the object-glass in the proportion $\frac{270.0}{274.4} = \frac{1}{1.016}$. The coefficient for the correction of the light of Jupiter for phase is 1.016. The altitude of Jupiter was 67°, and that of the Sun 45°. We must apply the coefficient $\frac{1}{1.045}$ to reduce the light of the planet for atmospheric extinction to the altitude of 45°. The ratio of the intensity of sunlight at the Earth and Jupiter is $\frac{r^2}{R^2} = 27.7$. The average brightness of the whole disc of Jupiter is less than that of the part included within the diaphragm, in the proportion 1 : 1.23. Lastly, the central element of Jupiter, which receives sunlight at perpendicular incidence, is brighter than the average of its disc in the proportion 1.43 : 1.

We then have

$$0.090 \times \frac{3}{4} \times \frac{1}{1.016} \times 1.016 \times \frac{1}{1.045} \times \frac{1}{1.23} \times 1.43 \times 27.7 = 2.1;$$

and therefore

$$\frac{\text{Albedo of white house}}{\text{Albedo of Jupiter}} = \frac{1}{2.1}.$$

The experiments were continued, and varied in the following way. The daylight was excluded from the dome, leaving only the object-glass exposed. The telescope being directed upon the object, the eye-piece lenses were removed, the focus diaphragm only remaining. The pencil of light admitted by the aperture in the diaphragm was then compared with the standard lamps, by equalizing the images of the two reflected

from glass globes, in the manner already described. It will be noticed that the aperture of the object-glass of the telescope has no influence in these experiments, and that no correction for its absorption is required, the proportion of light extinguished in passing through it being the same in all cases.

1860, March 26th. A fine clear sky. A few cumuli appeared before the close of the experiments. Aperture of object-glass, 5 inches. Focus aperture, $0^{in}.0425$; angular diameter at solar focus, $32''.47$.

Telescope directed upon the silvered glass globe B_2, diameter $3^{in}.436$, placed at a distance of 1336 feet from the object-glass, in a nearly horizontal line, azimuth 10° east of north, and the image of the Sun reflected from it, compared with the lamp *S*, diaphragm **Z**.

2h 1m	Sid. time.	Bulb to lamp *S*, 8.17 ft.	Bulb to focus, 5.85 ft.
2 9	"	" 8.13	" 5.85
2 15	"	" 8.30	" 5.85

Lamp *I* exchanged for *S*, using same diaphragm.

2h 25m	Sid. time.	Bulb to lamp *I*, 8.30 ft.	Bulb to focus, 5.85 ft.
2 29	"	" 8.70	" 5.85

Telescope directed to southeast side of a white house, at nearly the same distance and azimuth. This side of the house receives the direct sunlight at a small angle of incidence.

2h 43m	Sid. time.	Bulb to lamp *I*, 7.73 ft.	Bulb to focus, 5.85 ft.

Telescope pointed at the southwest side of the house, on which the direct light of the Sun falls at an angle of about 40°.

2h 52m	Sid. time.	Bulb to lamp *I*, 6.17 ft.	Bulb to focus, 5.85 ft.

A screen of white paper, painted with "Flake white" and "Chinese white," was placed at the same distance, perpendicular to the sunlight.

3h 2m	Sid. time.	Bulb to lamp *I*, 7.06 ft.	Bulb to focus, 5.85 ft.
3 5	"	" 7.30	" 5.85

Telescope pointed at a mass of trees without leaves, distant about 1000 feet, and 180° in azimuth from the Sun.

3h 20m	Sid. time.	Bulb to lamp *I*, 13.30 ft.	Bulb to focus, 5.85 ft.

The flames of the lamps were occasionally examined and found in good adjustment. The globe B_2 was placed within a hollow tin cone, near its apex. The cone was well blackened to cut off dispersed light, and the globe was frequently altered in position so as to expose different parts to the Sun.

1860, March 28th. Sky nearly, though not perfectly clear, especially in the later experiments. Adjustments as on 26th. Globe B_2 in same position. Lamp *S*, diaphragm **Z**.

1h 4m Sid. time.	Bulb to lamp *S*, 7.70 ft.	Bulb to focus,	5.85 ft.
1 4 "	" 7.70	"	5.85
1 14 "	" 8.00	"	5.85

Aperture changed to $14^{in}.94$.

1h 34m Sid. time.	Bulb to lamp *S*, 7.80 ft.	Bulb to focus,	5.85 ft.
	" 7.80	"	5.85
	" 5.05	"	5.85

Lamp *S* exchanged to *I*.

1h 44m Sid. time.	Bulb to lamp *I*, 7.45 ft.	Bulb to focus,	5.85 ft.
	" 7.85	"	5.85
	" 7.65	"	5.85

At the same distance, a screen of "Whatman's" drawing-paper painted with "Flake white" was set up, perpendicular to the Sun's rays, affording a surface of a pure white without gloss, sensibly more brilliant than new-fallen snow.

1h 59m Sid. time.	Bulb to lamp *I*, 6.40 ft.	Bulb to focus,	5.85 ft.
	" 6.50	"	5.85

Silvered globe B_3, diameter $1^{in}.760$, placed in the position described above for B_2.

2h 19m Sid. time.	Bulb to lamp *I*, 6.08 ft.	Bulb to focus,	3.00 ft.
	" 5.80	"	2.90

A screen of black cloth, washed with a thin size of indigo, to destroy the gloss and afford a dead blue-black surface, was set up at the same distance.

2h 39m Sid. time.	Bulb to lamp *I*, 11.10 ft.	Bulb to focus,	3.10 ft.

Clouds troublesome. The clear intervals were used.

1860, April 7th. Clear. Aperture of object-glass $14^{in}.94$. Compared image of Sun reflected from B_2, distant as before, 1336 feet, with lamp I, diaphragms **Z**, **M**, and **X**.

$1^h\ 4^m$ Sid. time.	Bulb to lamp I, diaphragm **Z**,	$6^{ft}.90$	Bulb to focus,	$5^{ft}.85$

Chalk-ball, G, painted pure flake-white, diameter $1^{in}.614$, exposed in same position to sunlight. It showed a phase like that of the Moon three days from full.

Bulb to lamp I, diaphragm **Z**,	$9^{ft}.85$	Bulb to focus,	$5^{ft}.85$

Lamp diaphragm altered to **M**.

Bulb to lamp I, diaphragm **M**,	$9^{ft}.60$	Bulb to focus,	$5^{ft}.85$

Silvered globe B_2 in same position.

Bulb to lamp I, diaphragm **M**,	$6^{ft}.50$	Bulb to focus,	$5^{ft}.85$

Lamp diaphragm altered to **X**.

	Bulb to lamp I, diaphragm **X**,		$20^{ft}.4$	Bulb to focus,	$5^{ft}.85$
$1^h\ 59^m$ Sid. time.	"	"	20.1	"	5.85

After applying the necessary corrections, we have the following for the results of the comparisons made by means of the lamps.

1860, March 26th. Southeast side of white house on which direct sunlight falls at small incidence. The same correction has been applied to reduce to direct illumination by sunlight at perpendicular incidence, that was used on March 23d.

$$\frac{\text{Albedo of house}}{\text{Albedo of Jupiter}} = \frac{1}{2.3}, \qquad \text{1 Obs.}$$

Southwest side of house. Angle of incidence of sunlight, 40°.

$$\frac{\text{Albedo of house}}{\text{Albedo of Jupiter}} = \frac{1}{1.5}, \qquad \text{1 Obs.}$$

White paper screen. Angle of incidence of sunlight, 90°.

$$\frac{\text{Albedo of white paper}}{\text{Albedo of Jupiter}} = \frac{1}{2.0}, \qquad \text{2 Obs.}$$

Trees without foliage. 180° in azimuth from Sun's.

$$\frac{\text{Albedo of trees}}{\text{Albedo of Jupiter}} = \frac{1}{7}, \qquad \text{1 Obs.}$$

1860, March 28th. Screen of white drawing-paper, painted with "Flake white."

$$\frac{\text{Albedo of white paper}}{\text{Albedo of Jupiter}} = \frac{1}{1.7}, \qquad \text{1 Obs.}$$

Screen of black cloth without gloss.

$$\frac{\text{Albedo of black cloth}}{\text{Albedo of white paper}} = \frac{1}{11}, \qquad \text{1 Obs.}$$

By an experiment subsequently made, (May 11th,) I found for the latter a considerably less value, viz.: —

$$\frac{\text{Albedo of black cloth}}{\text{Albedo of white paper}} = \frac{1}{17}, \qquad \text{2 Obs.}$$

The albedo of dark, weather-worn rocks, dry earth, sand, or gravel, I have found to be from $\frac{1}{5}$ to $\frac{1}{7}$ of that of the white paper, or about $\frac{1}{12}$ of that of Jupiter. Referring to the numbers given in (51), we are led to the inference that, while the general surface of the Earth is very much darker than Jupiter, its reflective power nearly resembles that of the Moon, agreeing with the comparison made by Herschel, before cited.

According to Lambert, the albedo of the whitest known substance* is 0.423, differing but very little from that of the whitest paper, $\mu = 0.410$.

Olbers† has suggested that fresh-fallen snow may be yet more brilliant; but, from actual comparison, I incline to think that the little difference between them is rather in favor of the paper. A very pure surface without gloss may be obtained by grinding two pieces of chalk upon each other, and afterwards coating them with "Flake" or "Chinese" white; still the difference between it and thick white paper, similarly coated, is but trifling.

If we suppose the albedo of the paper used in the foregoing experiments to be $= 0.4$, that of Jupiter will be 0.68, or larger by one half than the reflective power of the purest white surface that we can produce artificially.

Further confirmation of these results is much to be desired, especially when we bear in mind the unavoidable errors to which the observations are exposed, and the

* Kremnitz white, a fine white-lead.

† Monatliche Correspondenz, Vol. VIII.

somewhat precarious nature of the theory which has been adopted for expressing the distribution, in various directions, of the light reflected from the planet.

One such may be derived from Seidel's investigations upon the light of Jupiter compared with the fixed stars.*

He has obtained, for the proportion between the light of the Sun and that of α Lyræ, using Lambert's formula,

$$\text{Log.}\ \frac{\text{Sun}}{\alpha\ \text{Lyræ}} = 10.4499 - \text{log. albedo Jupiter.}$$

If we employ the values,

$$\text{Log.}\ \frac{\text{Jupiter at mean opposition}}{\alpha\ \text{Lyræ.}} = 0.9158,$$

$$\text{Log.}\ \frac{\text{Jupiter at mean opposition}}{\text{Mean Full Moon}} = 6.1918,$$

the first as deduced by Seidel, and the second taken from (33), we have

$$\text{Log.}\ \frac{\text{Mean Full Moon}}{\alpha\ \text{Lyræ}} = 4.7240\ ;$$

hence,

$$\text{Log.}\ \frac{\text{Sun}}{\text{Mean Full Moon}} = 5.7259 - \text{log.}\ \mu''.$$

This gives for the albedo of Jupiter

$$\mu'' = \frac{532000}{S},$$

in which, if we substitute

$$S = 550000,$$

the mean between the values determined by Bouguer and Wollaston, we obtain

$$\mu'' = 0.967.$$

Although not much dependence can be placed in the value of S,† on which this determination rests, it deserves attention that the result is of the same character with

* Untersuchungen über die Lichtstärke der Planeten Venus, Mars, Jupiter, und Saturn, München, 1859.

† The new determination of S, referred to in the note on p. 266, gives $\mu'' = 1.18$.

those before investigated. Thus all the experiments agree in indicating that the planet reflects to the Earth more than twice as much light as would have been expected from *a priori* considerations. The disproportion is the more remarkable on account of the bright bands, and especially of the brilliant white spots occasionally seen on the surface of Jupiter. From the best estimates which I have been able to make, the whitest bands are brighter than the average surface in a proportion larger than 3 : 2.

This has been ascertained by drawing belts of different intensity upon a sphere held at a distance of twelve or fifteen feet from the eye, and, judging of their resemblance to the belts upon Jupiter, by viewing the two objects alternately. The contrast of tints having been decided upon, the sphere was afterwards compared with paper of different shades placed at suitable distances from a lamp to give a similar contrast. The ratio of the squares of the distances furnished a measure of the quantities of light given by each.

Assuming that the dusky belts, at the time when the comparisons were made, (in April, 1860,) occupied one fourth of the surface, I have found,

$$\frac{\text{Albedo of principal dusky belts}}{\text{Albedo of rest of surface}} = \frac{1}{1.51},$$

$$\frac{\text{Albedo of actual surface of Jupiter}}{\text{Albedo of Jupiter if destitute of dark belts}} = \frac{1}{1.13}.$$

The average brilliancy of the surface, exclusive of the dark belts, is about intermediate between the bright and the dark belts; hence,

$$\frac{\text{Albedo of narrow, very white belts}}{\text{General albedo of whole surface}} = 1.13 \times 1.51 = 1.70.$$

From the accounts which many observers have given of the brightness of the white faculæ, it seems quite possible that their light may be even more than double that of the rest of the surface, and that the darker spots are in an equal degree fainter.

By admitting that Jupiter shines in part by native light, it is of course easy to explain its apparent excess of brightness. The planet is probably enveloped in a dense mantle of clouds, and we know that in our own atmosphere the luminosity of the clouds is a well-established fact. The more brilliant auroral exhibitions, too, are unquestionable evidence that the Earth itself shines with a certain amount of native light, and to suppose a similar property in Jupiter is introducing no very improbable hypothesis. On the other hand, the phenomena of the transits of the shadows of the satellites of Jupiter over its disc show that the greater part, certainly, of the light

with which it shines is derived from the Sun. These shadows appear dark enough to imply a contrast of probably more than 1 to 3 between the areas covered by them and the surrounding bright surface upon which they are projected. Discs of shaded paper, having to the unassisted eye an angular diameter equal to the visual angle subtended by the shadows of the satellites when viewed through the telescope, projected upon a background reflecting three times as much light, may be described as "dusky" or "dark" in comparison, but scarcely "black," which latter term is not unfrequently applied to the appearance of the shadows of the satellites, in telescopes with powers sufficient to give to their discs a visual angle of 2′ or 3′.

It cannot, with any degree of probability, be supposed, that, in ascribing this high albedo to Jupiter, we have been misled by using Lambert's theory in the reductions, for a departure from this theory, as respects the distribution of the light reflected from the planet, sufficient to account for a large excess of illumination from the full phase, would in all likelihood manifest itself in causing the margin of the disc to appear brighter than the centre, just as occurs with the Moon; but it is certain that the margin of Jupiter is much fainter than its centre, the distribution agreeing, in this particular, sufficiently well with the results of Lambert's theory.

This is proved by the changes which the appearance of the satellites, particularly the third, undergoes, as they transit the disc. The third satellite has been repeatedly seen as a "dark" or "black" spot projected upon the white surface of the planet; when, however, the entire transit is observed, it is always seen to enter upon the planet as a small *white* disc on a darker ground; very soon its brilliancy fades, and it is lost to sight, presently reappearing, farther advanced in its transit, as a dark or black spot, and continuing under this aspect until it has accomplished perhaps three fourths of its journey, when it again repeats, in reverse order, the changes attending the entrance, and before its final egress it is white once more.

The most curious phenomenon exhibited by the satellite under these circumstances is that in its central position it should become so dark as not to be distinguishable in blackness from its own shadow projected side by side with it.*

The explanation commonly offered of this singular phenomenon, viz. that there are large spots upon the satellites which become visible when projected upon a bright back-

* From observations made with the great refractor of the Observatory on a great number of occasions during the past twelve years, it seems that the above or analogous changes of aspect are always presented by the third and fourth satellites in their transits. The first and second satellites either disappear if projected on dark belts, or if on white ones they become dark or dusky spots, though invariably of a brilliant white when close to the margin.

ground, is an error; for since they become relatively darker than the planet only when at a considerable distance within the limb, it is plain that a constant period of rotation of the satellite on its axis will not account for its always becoming white when near its egress, so as to present precisely the same aspect that it has just after its ingress, whether the chord described over the disc of Jupiter be large or small. This alone is a sufficient objection to the proposed explanation; it is, moreover, inconsistent with the change of aspect which the satellites must present to the Earth when in conjunction with the primary, in consequence of the revolution of Jupiter about the Sun.

There is no way, in fact, of accounting for the phenomenon in question, except by supposing that the central regions of Jupiter are so much brighter than the parts towards the circumference, that an object, of an intensity intermediate between the two, is made, by the mere effect of contrast, to appear white when projected upon the latter, and dark when projected upon the former. This implies a disproportion greater than 1 : 6 between the whiteness of the satellite and of the bright belts of Jupiter, as I have found by experiments similar to those related above.

This defect of brightness near the limb, as has been before remarked, authorizes the application to this planet of Lambert's principle of opaque reflection, and scarcely leaves us at liberty to assume that a much larger proportion of the whole light reflected is directed towards the Earth than that principle allows. Perhaps, however, by admitting a tendency in this direction, and remembering that a reflective capacity equal to that of the whitest substances known to us probably belongs to the sunward side of the clouds in our atmosphere, and not less so to the cloud-mantle in which Jupiter is enveloped, we may have a more acceptable explanation of its remarkable brilliancy than to suppose it to be in any degree self-luminous. If Venus, like Jupiter, be surrounded by a dense envelope of clouds, — a supposition otherwise quite in keeping with its physical aspect, — the difficulty of accounting for its high albedo would be considerably lessened. Its excess of light when in the half of its orbit nearest the Earth would then be merely an example of the phenomenon presented by the dazzling whiteness of clouds in our atmosphere when seen near the Sun.

Erratum. — On p. 225, *for* $S = 477530$, *read* $S = 470980$.

IX.

Comparison of the Light of the Sun and Moon.

By GEORGE P. BOND.

(*Communicated September* 11, 1860.)

In the preceding memoir, allusion has been made to the values found by Bouguer and Wollaston for the ratio between the light received at the Earth from the Sun and the Full Moon. The numbers given by them respectively are: —

Bouguer,*	$S = 300\,000$,
Wollaston,†	$S = 801\,072$.

The discordance is large enough to excite a doubt whether they may not both be entirely illusory; it will not, then, be uninteresting to re-examine the processes which these eminent physicists have followed in their investigations, and to add the results of new experiments depending on quite different methods.

The method of Bouguer is thus described by Arago: ‡ —

"On the day of observation, the Sun being at an altitude of 31°, and his rays entering a dark chamber through a hole $\frac{1}{12}$ of an inch in diameter, he placed a concave lens in front of this aperture, which diminished the intensity of the solar rays by causing them to diverge.

"Then receiving this divergent light on a screen, at a distance where it was weakened in the proportion of 1 to 11664, he found it equal to that of a candle situated at the distance of 17 inches from the screen.

"Repeating this experiment at night with the moonlight and the same concave lens, the Moon being full and also at an altitude of 31°, Bouguer perceived that the light, when it had been made to diverge $\frac{7}{10}$ of an inch, or when it had been weakened

* Traité d'Optique, p. 87.

† Phil. Trans., 1829, p. 27.

‡ Popular Astronomy, English Translation, Vol. II. p. 288. The distances have been reduced by the translators approximately to English measures.

only by one sixty-fourth, was already so faint that the candle had to be put at a distance of 53.2 feet before the two lights could be rendered equal. Hence we find by a suitable calculation that the Sun illuminates the Earth's surface 256,289 times more than the Moon does.

"Three similar experiments, made at various seasons of the year 1725, yielded the following results to M. Bouguer: 284089; 331766; 302500. Whence the celebrated academician concluded that the proportion of sunlight to moonlight, when the Moon is at her mean distance, is as 300000 to 1."

Bouguer's detailed account is given in the *Traité d'Optique*, from which the following extract is made.

"Il falloit, selon notre méthode, comparer la lumière de ces deux astres avec celle d'une bougie ou d'un flambeau qui servît de mesure commune; mais comme la lumière du soleil est extrêmement forte, il falloit lui faire souffrir de très-grandes diminutions, et il falloit que ces diminutions se fissent toujours par des degrés connus. Je me servis pour cela d'un verre concave de lunette, qui rendoit les rayons très-divergents; et je n'avois qu'à m'en éloigner un peu plus ou un peu moins, pour faire varier la force de la lumière tout-à-coup, et en quelle proportion je voulois. Je fis un de ces essais le 22 Septembre, 1725, jour de la pleine lune: ayant fermé toutes les fenêtres d'une chambre, et le soleil étant élevé de 31 degrés, je fis entrer sa lumière par un trou qui avoit une ligne de diamètre, et sur lequel j'avois appliqué le verre concave. Recevant ensuite la lumière à une distance de 5 à 6 pieds, dans un point où la divergence des rayons étoit de 108 lignes, et où la lumière étoit par conséquent affoiblie 11664 fois, puis qu'au lieu de n'occuper qu'un espace d'une ligne de diamètre, elle en occupoit un qui en avoit 108, et qui étoit 11664 fois plus grand; elle me parut exactement égale à la lumière d'une bougie située à 16 pouces de distance. Il ne me restoit plus, après cela, qu'à faire pendant la nuit une semblable observation sur la lune, et il me falloit employer toujours le même verre concave, afin que son défaut de transparence causât une semblable diminution dans une observation que dans l'autre. J'attendis le temps que la lune eût 31 degrés de hauteur; mais en recevant sa lumière fort proche du verre, et lorsque la divergence des rayons n'étoit que de 8 lignes, elle avoit déjà si peu de force, qu'il me fallut faire mettre la bougie à 50 pieds de distance pour rendre les deux lumières égales.

"Pour trouver maintenant le résultat de ces deux observations, on n'a qu'à considérer que la lumière de la lune n'a été affoiblie que 64 fois par le verre concave, et que si on l'avoit fait diminuer 11664, de même que celle du soleil, il auroit fallu mettre ensuite la bougie, non pas à 50 pieds de distance, mais à 675. Or, puisque la lumière

du soleil, lorsqu'elle est diminuée 11664 fois, est égale à celle d'une bougie placée à 16 pouces de distance, comme nous l'avons reconnu par la première observation ; et que la lumière de la lune diminuée un même nombre de fois, n'est égale qu'à celle de la même bougie portée à 675 pieds ou à 8100 pouces de distance, comme on le conclut de la seconde observation, il s'ensuit que la lumière du soleil est à celle de la lune, comme 65610000 (qui est le quarré de 8100), est à 256 (qui est le quarré de 16). Ainsi il paroît que le soleil nous éclaire environ 256289 fois plus que la lune.

"Je ne rapporte ici que la troisième des épreuves que j'ai faites ; car à la pleine lune de Juillet 1725, j'avois trouvé que le soleil nous éclaire 284089 fois plus que la lune ; à celle d'Août 331776 fois, et par une autre épreuve 302500 fois. Je crois qu'on pourroit conclure de tout cela, que le soleil nous éclaire environ 300000 fois plus que la lune ; mais les grandes difficultés qu'il y a à déterminer un semblable rapport, font que je n'ose pas le regarder comme exact. Cependant il est toujours bon de faire remarquer que la lune étoit à-peu-près dans ses moyennes distances à la terre, lorsque je faisois mes observations." *

Apart from the uncertainty inseparable from photometric determinations of every description, there seems to be no just ground for questioning the reliableness of these experiments, unless it be on account of the difference of *color* between sunlight or moonlight, and the candle-light, which is, indeed, very considerable. But on the other hand, it may be urged that, if the Sun and Moon are themselves similar in color, the effect of a different tint in the light of the candle will be of comparatively little consequence, as it would be likely to bias the estimates of the observer in the same direction for both objects and in equal proportions, so that the error would fall chiefly upon the comparison between either of them and the candle, and would be eliminated when the two were referred to each other.

If, for instance, the light of two objects, whose relative brightness is to be ascertained, were white, and that of the intermediate standard were red ; and if the observer habitually and consistently over-rated the intensity of light of the latter hue ; the proportion between the former, derived from his estimates, would still be unaffected by this peculiarity. It must be confessed, however, that the vast difference in the intensity of the two luminaries and other influences prejudicial to accuracy deprives such inferences, in the case of the Sun and Moon, of much of their force, and the conclusions are still felt to be precarious, and must be fortified from other and independent sources.

* Traité d'Optique, p. 85.

Wollaston furnishes the following account of his mode of procedure.*

"The Sun's light was compared with that of a candle, by admitting a beam of it into a room through a small circular hole in a plate of metal, fastened in a window-shutter; and a small cylinder of any opaque material being placed in the beam, so as to cast a shadow upon a screen, the distance of a candle from the same cylinder (or an equal one placed at the same distance from the screen) was varied, until the shadow in the line of the candle became equally intense with the shadow in the line of the Sun. The direct light of the Moon was compared with the light of a candle in the same manner. . . . . .

"It appears from the mean of the observations given in No. V. of the Appendix, that the light of the Sun is equal to that of 5,563 candles placed at the distance of one foot; a result which accords very nearly with that of Bouguer. For he states the light of the Sun to be equal to that of 11,664 wax-candles at the distance of 16 inches French, which is equivalent to 5,774 wax-candles at the distance of one foot English. It appears also from my experiments, that the light of the full Moon is equal to $\frac{1}{144}$ part of the light of a candle, placed at the distance of a foot; and hence that the Sun's light is equal to 5,563 × 144 × Moon's light = 801,072 × Moon's light. Bouguer, who differs greatly from me in the comparison of the Moon with a candle, states the light of the Sun to be = 300,000 × Moon's light."

The observations referred to, are here transcribed:†—

"*V. Observations of the Light of the Sun, compared with that of a Candle, by Means of Shadows.*

Date of the Observation.	*H* Diameter of the Hole in the Shutter in Parts of an Inch.	*D.* Distance of the Hole from the Screen in Inches.	*C.* Distance of the Candle from the Screen in Inches, when its Light is equal to that of ☉, admitted through Hole.	Numerical Value of the Expression $\left[\frac{12 \times D}{C \times H} \times 2 \tan. ☉\text{'s} \frac{\text{Diam.}}{2}\right]^2$.
1799. End of May	0.0067	93	19.5	6152
and	.0072	93	19.0	5611
Beginning	.0087	93	18.0	4382
of June.	.0093	93	17.5	3965
	.0093	111.5	20.5	5228
	.0098	102	14.25	6477
	.0098	108	$15\frac{1}{6}$	6410
	.0098	120	17.0	6299
May 28	.0098	120	17.5	5944
June 19	.0105	126	15.0	7770
	.0111	93	14.5	4054
	0.0118	93	13.0	4463
				66755

$$\frac{66755}{12} = 5563.$$

* Philosophical Transactions, 1829, p. 20, *note*. † Ibid., p. 27.

Hence 5,563 is the number of candles which, being placed at the distance of 12 inches, will give a light equal to that of the Sun.

"*VI. Observations of the Light of the Moon compared with that of a Candle by Means of Shadows.*

Date of the Observation.	Remarks.	Distance, in Inches, of the Candle from a Screen, when its Light is equal to that of ☾.
1799, May 16	☾'s Elongation $170\frac{1}{2}°$	144
.... June 17	☾ Full	144

Hence

$$☾ = \frac{1}{144} \times \text{Candle when placed at the distance of twelve feet,}$$

and

$$\odot = 5563 \times \left(\frac{144}{12}\right)^2 \text{ Moons.}$$

$$= 801{,}072 \text{ Moons."}$$

In two particulars which may have exercised a considerable influence, Wollaston's experiments seem to be less deserving of confidence than those of Bouguer.

It does not appear that, in the former, the extinction of light by the Earth's atmosphere has been allowed for. The Sun was in a high northern declination, and the Moon far to the south of the equator; indeed, at the date of the second observation, in its extreme southern declination of 28°, with a meridian altitude in the latitude of London of only 10° or 11°. Unless, then, special care was taken to observe the Sun when equally near the horizon, of which there is no evidence, it would seem that the moonlight must have been relatively much too faint by reason of the ordinary atmospheric extinction. At the date of the last comparison, it must have been from this cause less than half as bright as it would have been at the meridian altitude of the Sun, and still fainter, if we take into account the smoky atmosphere of London, where the experiments were probably made.*

Another objectionable feature is the means employed for diminishing the sunlight by admitting it only through a very small aperture, while for the Moon the full disc

* Supposing each to have been observed when near the meridian, the effect of atmospheric extinction would have been to cause the Moon to appear, in the mean of the comparisons, too faint relatively to the Sun, in the proportion 6 : 10. Wollaston's ratio of sunlight to moonlight would then be

$$0.6 \times 801\,072 = 480\,643,$$

or

$$S = 480\,643.$$

was compared. It is not clear that these dissimilar conditions may not have occasioned some disturbance in the results. Bouguer, by using the same aperture upon both objects, has avoided this risk of error. It is, however, to be remarked, that the point of divergence as noticed by Wollaston is in the comparison between the Moon and the candle-light. For the Sun, they find respectively,

Wollaston,	Sunlight =	5563 Candles at 1 English foot distance.
Bouguer,	" =	5774 " " "

But on the other hand,

Wollaston,	Moonlight =	$\frac{1}{144}$ Candle at 1 English foot distance.
Bouguer,	" =	$\frac{1}{52}$ " " "

Lambert* has compared the Moon with the light of a tallow-candle, and found the latter, at a distance of 1 foot English, 44 times as bright as moonlight. My own experiments give 62 for the same ratio, using a wax candle.

Though no great reliance can be placed on the constancy of the candle-light used in the different experiments, yet it is to be noticed that Wollaston's result diverges widely from the mean of the other determinations, and in a direction and to an amount which would be sufficiently well explained by supposing that the atmospheric extinction had not been considered, in reducing the observations of the Moon; in the other experiments, its influence was much less sensible.

Wollaston has also attempted a comparison of the light of the Sun and of Sirius and α Lyræ, by using, as an intermediate standard, the image of a candle reflected from a small thermometer-bulb, equalizing it first with the image of the Sun reflected from a similar bulb placed at a suitable distance, and then with the star. The images both of the Sun and of the star were viewed through a telescope provided with a colored screen to give them the same tint with the candle-light. The atmospheric extinction has been eliminated by making the observations at nearly equal altitudes.

The mean result, supposing none of the incident light to be absorbed by the bulbs reflecting the Sun's image, is:—

Sun's light = 11 839 533 000 × the light of Sirius;

but allowing for the loss of nearly half the Sun's light in reflection, Wollaston finds

Sun's light = 20 000 000 000 × the light of Sirius.

* Beer, Grundriss des Photometrischen Calcüles, p. 71.

We may connect this result with the comparisons instituted between the Sun and the full Moon by the following process.

Seidel's photometric determination of the relative brightness of the planet Jupiter, at its mean opposition, compared with Sirius, gives

$$\text{Log.} \frac{\text{Jupiter at mean opposition}}{\text{Sirius}} = 0.2952.^*$$

We have found in the preceding memoir,

$$\frac{\text{Jupiter at mean opposition}}{\text{Mean Full Moon}} = \frac{1}{6430};$$

hence,

$$\frac{\text{Sirius}}{\text{Mean Full Moon}} = \frac{1}{12688}.$$

Applying this to Wollaston's ratio between the light of Sirius and the Sun, we obtain

$$\frac{\text{Sunlight}}{\text{Full Moonlight}} = S = 1\,576\,100,$$

which is nearly twice as large as the value obtained by the previous method. There can be no question that the discrepancy lies with the original data rather than in the numbers which have been used to refer the light of Sirius to the Moon.

The proportion of 9 to 1, which Wollaston has assigned to the light of Sirius and *a* Lyræ by a similar method, is, according to the very carefully conducted researches of Seidel, more than twice too large.

With such discordances in the results of the different experiments, it is of importance to vary as much as possible the methods of investigation, in order to render them quite independent of each other, so far as the nature of the subject will permit. The three principal sources of difficulty encountered are, — the extreme intensity of sunlight; the difference in color between the light of the Sun or Moon, and that of the ordinary kinds of artificial illumination; lastly, the want of a constant standard of brightness, to which either object may be referred. The best intermediate standard, as regards the quality of the light, would undoubtedly be some form of the electric light, if its constancy could be maintained for a sufficient interval; all other artificial standards have greatly inferior intensity, and a more or less decided red or yellow hue when contrasted with solar light, and even with moonlight, which was scarcely to have been anticipated.

* Seidel, Untersuchungen über die Lichtstärke der Planeten Venus, Mars, &c., p. 35.

The image of the Drummond light compared with the image of the Sun, both reflected from a silvered globe, has a strong golden-yellow hue. The "Bengola light" answers much better. It shows, however, a decided tinge of pink when brought side by side with the pure white of the solar image. At night it is of an intense white, with a bluish glare; but when contrasted with the Moon's image it exhibits a striking similarity in quality of light, with only the very slightest cast of pink at times suspected, of the same character with that noticed in the experiments on the Sun, but no trace of the blue can then be detected. It seems, then, that in point of color the light of the Sun and that of the Moon are very nearly similar.

The first experiments for determining the ratio of sunlight to moonlight had reference to their chemical intensities, and gave the proportion,

$$\frac{\text{Chemical intensity of sunlight}}{\text{Chemical intensity of moonlight}} = S' = 340\,000.$$

The reader is referred to the Memoir preceding for a more detailed statement.

By diminishing the aperture of the object-glass of the 23-foot refractor until a circular area of only $0^{\text{in}}.021$ diameter was exposed, and viewing a small portion of the Sun's disc, subtending a diameter of $32''.47$, the intensity was estimated to be equal to that of an equal disc of Jupiter seen with an aperture of $14^{\text{in}}.94$; the eye having been guarded from exposure to daylight, and its judgment assisted by different combinations of colored screens used alternately upon both objects. After applying the necessary reductions for atmospheric extinction, for the distribution of light over the discs of the two bodies, and other conditions which need not be explained in detail, as the experiment can be at best but a rude essay, we obtain the value,

$$\frac{\text{Sunlight}}{\text{Light of Jupiter at mean opposition}} = 927\,000\,000,$$

from which, by using, as above, 6430 for the ratio of the light of the full Moon to Jupiter, we deduce

$$S = 144\,000.$$

A second method employed was to place a silvered glass globe at a distance of about one fourth of a mile, and to compare the image of the Sun reflected from it, and seen with a telescope from a darkened room, with a small disc of the flame of a Carcel lamp; this was subsequently referred to the light of Jupiter and the Moon, seen with the same telescope. The result furnished the value,

$$S = 375\,600.$$

This, again, is not entitled to much confidence, principally because the experiments for determining the absorption of sunlight by the reflecting surface of the globe failed to give a satisfactory result.

Of the different methods tried, that which seemed best fitted for the purpose will now be described; — the results of other attempts will be omitted, because they were in part only preliminary trials, and in some instances they were vitiated through neglect of precautions to which due attention was afterwards given. It should, however, be noticed that they all indicate a value of S less than 500 000.

The standard illuminator was a single Bengola light, those of the same size and manufacture being used throughout.

1860, July 1. A fine sky, perfectly clear. A glass globe, B_5, having a reflecting surface of silver, (applied by Liebig's process,) $10^{in}.16$ in diameter was placed in the open air exposed to the sunlight. The brightness of the image of the Sun formed at its virtual focus was compared with a single Bengola light, by receiving the light of both objects upon a small reflecting sphere, which was moved towards one or the other until their images, seen in it side by side, were judged to be equal; the distances of the globes from each other and from the Bengola were then measured, and the observation repeated.

$4^h\ 45^m$	Sid. time.	Bengola to Photometer,	$15^{ft.}$
		Globe B_5 "	20
4 50	"	Bengola to Photometer,	21.2
		Globe B_5 "	24.4
4 55	"	Bengola to Photometer,	18.4
		Globe B_5 "	21.5

On each occasion a new Bengola was burned, and the position of B_5 was altered so as to expose a new portion of its surface to the Sun.

1860, July 14. Clear. Observations on same image in B_5 continued.

$3^h\ 45^m$	Mean solar time.	Bengola to Photometer,	$28.0^{ft.}$
		Globe B_5 "	30.6
3 50	"	Bengola to Photometer,	40.5
		Globe B_5 "	52.2

The sensible equality in the intensity of the light reflected in different directions from the globe B_5 was tested experimentally by comparing with the photometer the image of the Sun reflected from it with the Sun image in a similar globe of smaller

dimensions placed at a distance from it, under angles of incidence differing by large amounts; only when the reflected image was viewed from a position which brought it nearly into a line with the Sun, was there any noticeable change of brightness, and this was easily accounted for by the well-known fact, that the reflective power of a surface not perfectly polished is greatest when the angle of incidence is least. This extreme position, however, was not approached when the comparisons between the Sun and Moon were made.

From the above, after applying small corrections for atmospheric extinction, and to refer the sunlight to its amount corresponding to the mean distance of the Earth from the Sun, we have

$$\text{Log. } \frac{\text{Bengola}}{\text{Sun's image in } B_5} = 9.801 \qquad \text{July 1st.}$$

$$\text{"} \qquad = 9.786 \qquad \text{" 14th.}$$

$$\text{Adopted, } \quad 9.793$$

The next step was to compare, in precisely the same way, the image of the Moon reflected from the globe B_5 with the Bengolas; this was effected on July 31st, the Moon being nearly full.

1860, July 31. Sky fine and perfectly clear.

Globe B_5 in open air exposed to moonlight, and the reflected image compared with single Bengolas in the same way as had been done with the Sun.

(*a*)	18h 15m	Sid. time.	Bengola to Globe B_5		= 982 ft.	Distance of foci of B_5 and Photometer Globe,	1.65 ft.
(*b*)	25	"	"	"	1682	"	2.48
(*c*)	30	"	"	"	1682	"	2.08
(*d*)	44	"	"	"	1718	"	2.38
(*e*)	50	"	"	"	1718	"	2.53
(*f*)	55	"	"	"	1718	"	2.84

The following corrections must be applied to reduce the comparisons to the brightness of the full Moon in the zenith, and at its mean distance from the Earth and from the Sun.

For atmospheric extinction:—

Comparison (*a*),		Log. correction	= 0.174
"	(*b*), (*c*),	"	= 0.148
"	(*d*), (*e*), (*f*),	"	= 0.129

For the Moon's distance from the Earth and Sun: —

Moon's geocentric semidiameter		= 902″.1	
Augmentation for altitude of 24°		= 6.4	
		908.50	log. = 2.9583
Moon's mean semidiameter		934.67	" = 2.9707
			0.0124
			2
			0.0248
Log. Earth's radius vector,	0.0063		
	2		
	0.0126	. . . .	0.0126
Log. cor. to Moon's mean distance from Earth and Sun			= 0.0374

For the imperfect illumination of the Moon's disc: —

Angle of elongation of Moon from Sun	= 172°.4
Log. corresponding correction for phase,*	0.013

The sums of the above logarithmic corrections are: —

Comparison (*a*),	Log. correction	= 0.224
" (*b*), (*c*),	"	= 0.198
" (*d*), (*e*), (*f*),	"	= 0.179

The distances of the foci of the globes from each other and from the Bengola give, after applying the above corrections,

(*a*),	$\text{Log.}\ \frac{\text{Bengola}}{\text{Image of mean Full Moon in } B_5}$	= 5.324
(*b*), (*c*),	"	= 5.537
(*d*), (*e*), (*f*),	"	= 5.466
	Mean by weights, ...	5.466

Comparing this with the result just obtained for the intensity of the Sun's image reflected from the same globe, we have, finally,

$$\text{Log.}\ \frac{\text{Image of mean Sun in } B_5}{\text{Image of mean Full Moon in } B_5} = 5.466 - 9.793 = 5.673;$$

or,

$$S = \frac{\text{Light of mean Sun}}{\text{Light of mean Full Moon}} = 470\,980.$$

* Derived from the table of values of log. H_0 in the preceding Memoir.

The following numbers represent the proportions of light emitted by various celestial objects. They are taken from the preceeding Memoir of this volume, and depend in part upon the experiments of Herschel and Seidel.

$$\frac{\text{Jupiter at opposition}}{\text{Mean Full Moon}} = \frac{1}{6430}, \qquad \frac{\text{Jupiter at opposition}}{\text{Venus at greatest brilliancy}} = \frac{1}{4.864}.$$

$$\text{Log. } \frac{\text{Jupiter at opposition}}{\alpha \text{ Lyræ}} = 0.9158,$$

$$\text{“} \quad \frac{\text{Sirius}}{\alpha \text{ Lyræ}} = 0.6210,$$

$$\text{“} \quad \frac{\alpha \text{ Centauri}}{\alpha \text{ Lyræ}} = 0.1200,$$

$$\text{“} \quad \frac{\text{Rigel}}{\alpha \text{ Lyræ}} = 9.9890,$$

$$\text{“} \quad \frac{\text{Spica}}{\alpha \text{ Lyræ}} = 9.6810,$$

$$\text{“} \quad \frac{\alpha \text{ Aquilæ}}{\alpha \text{ Lyræ}} = 9.6810,$$

$$\text{“} \quad \frac{\text{Fomalhaut}}{\alpha \text{ Lyræ}} = 9.5260.$$

These, combined with the ratio of the light of the Sun and Moon, give the relations,

Sunlight	=	470 980	times the light of the mean Full Moon,		
“	=	622 600 000	“	“	Venus at maximum brilliancy,
“	=	3 028 350 000	“	“	Jupiter at mean opposition,
“	=	5 970 500 000	“	“	Sirius,
“	=	18 924 000 000	“	“	α Centauri,
“	=	24 946 500 000	“	“	α Lyræ,
“	=	25 586 500 000	“	“	Rigel,
“	=	52 001 000 000	“	“	Spica,
“	=	52 001 000 000	“	“	α Aquilæ,
“	=	74 303 500 000	“	“	Fomalhaut.

A Catalogue of the Declinations of 532 Stars culminating near the Zenith of the Observatory of Harvard College, Cambridge.

By T. H. SAFFORD.

(*Communicated September* 11, 1860, *by* G. P. Bond.)

The Catalogue here communicated was originally prepared at the Observatory of Harvard College, at the request of Captain George G. Meade, of the United States Topographical Engineers, for the use of the Survey of the North and Northwest Lakes, in the determinations of latitudes with the zenith telescope, according to the method proposed by Talcott. The method requires for its successful application the combination of pairs of stairs distant generally less than 10° from the zenith of the place of observation, and having accurately determined positions. The present collection has been the result of a careful discussion of the positions of the stars included, as given by the best existing authorities,* and is intended to facilitate the determinations of latitudes at stations near the northern boundary of the United States.

G. P. BOND,
Director of the Observatory of Harvard College.

The following notation has been employed for the Catalogues used in this discussion:—

M. *Die Eigenbewegung der Fixsterne in ihrer Beziehung zum Gesammtsystem, von J. H. Mädler.* Dorpat. 1856. 4to.

Br. *Fundamenta Astronomiæ pro Anno* 1755, *deducta ex Observationibus Viri incomparabilis James Bradley in Specula astronomica Grenovicensi per Annos* 1750 – 1762 *institutis Auctore F. W. Bessel.* Regiomonti, 1818. Fol.

Fed. *Positions moyennes pour l'epoque de* 1790.0 *des étoiles circompolaires dont les observations ont été publiées par Jérome Lalande, dans les mémoires de l'acadé-*

* The Armagh "Places of 5345 Stars" recently published, was not received in season to be included among the authorities.

mie de Paris de 1789 *et* 1790. *Par Ivan Fedorenko.* St. Pétersbourg. 1854. 4to.

L. *A Catalogue of those Stars in the Histoire Céleste Française of Jérome de la Lande, for which Tables of Reduction to the Epoch* 1800 *have been published by Professor Schumacher. Reduced under the immediate Superintendence of the late Francis Baily, Esq.* London. 1847. 4to.

Gr. *A Catalogue of Circumpolar Stars, deduced from the Observations of Stephen Groombridge, Esq., edited by G. B. Airy, Esq., A. M., Astronomer Royal.* 1838. 4to.

Str. *Stellarum Fixarum imprimis duplicium et multiplicium Positiones mediæ pro Epocha* 1830.0 *deducta ex Observationibus Meridianis Annis* 1822 *ad* 1843 *in Specula Dorpatensi institutis ; Auctore F. G. W. Struve.* Petropoli. 1852. Fol.

T. *A general Catalogue of the Principal Fixed Stars, from Observations made at the Honorable the East India Company's Observatory at Madras, in the Years* 1830 – 1843, *by Thomas Glanville Taylor, Esq., F.R.S., F.R.A.S., Astronomer to the Honorable Company.* Madras. 1844. 4to.

R. *Mittlere Oerter von* 12000 *Fix-sternen für den Anfang von* 1836, *abgeleitet aus den Beobachtungen auf der Hamburger Sternwarte von Carl Rümker.* Hamburg. 1843. Oblong 4to.

Arg. DLX. *Stellarum Fixarum Positiones mediæ ineunte Anno* 1830, *Auctore Argelandro.* Helsingforsiæ. 1843. 4to.

Pi. *Præcipuarum Stellarum inerrantium Positiones mediæ ineunte Sæculo* XIX. *Auctore Piazzio.* Panormi. 4to. 1814.

Ai. *Catalogue of* 2156 *Stars, formed from the Observations made during Twelve Years, from* 1836 *to* 1847, *at the Royal Observatory, Greenwich.* London. 1849. 4to.

J. *Observations made at the Radcliffe Observatory, Oxford, in the Years* 1840 – 1853, *under the Superintendence of Manuel J. Johnson, M. A., Radcliffe Observer.* Volume I. – XIV. Oxford. 1842 – 1855. 8vo.

Ja. *A Subsidiary Catalogue of* 1440 *Stars selected from the British Association Catalogue, reduced to January* 1st, 1850, *from Observations made at Madras in the Years* 1849 – 1853 [*under the direction of Capt. W. S. Jacob*]. (No date or place of publication.) 4to.

Ou. *Dissertatio Astronomica Inauguralis exhibens Observationes ope Instrumenti Transitorii portabilis institutas. . . .* [*Auctore J. A. C. Oudemans.*] Lugduni Batavorum. [1852.] 4to.

Ai. 2. *Observations made at the Royal Observatory, Greenwich, in the Years* 1853–1857, *under the Direction of George Biddell Airy, Esq., M. A.* London. 1855–1859. 5 vols. 4to.

J. 2. *Observations made at the Radcliffe Observatory* [*etc.* as above. 1854–1857]. Volume XV.–XVIII. Oxford. 1856–1859. 8vo.

The Catalogue *M.* contains the places for 1850.0 of the stars in Bessel's "Fundamenta," and the positions given are deduced from a discussion of previous Catalogues, including those cited above, with the exception of *Ja.*, *J.* 2, and *Ai.* 2; including also, as I have assumed, the Greenwich Observations till 1852 inclusive. For many of the stars in the following list, therefore, the places from *M* are reduced to 1859, and given as definitive. For others, the places from the Catalogues *Ai.* 2, *Ja.*, and *J.* 2 are annexed to those from *M.* In such case, the proper motion given by Mädler has been used to reduce the other Catalogue places to 1859, and the number of observations employed by Mädler in his discussion has been divided by 2, to get the weight assigned to Mädler's place. Each observation from *Ai.* 2 or *J.* 2 has received the weight 1, and each one from *Ja.* the weight .5.

The systematic corrections employed to reduce the Catalogues to the zero of Mädler have been those taken from his discussion, so far as applicable; and for the Catalogues *J.* 2, *Ai.* 2, and *Ja.*, a separate examination has been made.

A few of Mädler's positions have been unemployed, the stars being discussed anew. The remaining stars of the following list, those not occurring in the Fundamenta, have been discussed by employing the systematic differences given by Mädler and on pp. 302, 303, to reduce, with the aid of Bessel's precession, the observed positions to 1859. Comparisons, then, between ancient observations (generally Groombridge's of 1810) and the modern ones (referring in general to a time about 1845) have given approximate proper motions by which they could be referred to 1859.

The right ascensions have been taken (to seconds) from the British Association Catalogue, except in one or two cases, where obvious errors existed in some of the Catalogues from which that was formed. Its annual variation to 0ˢ.1 is given under the heading Annual Variation. The magnitudes have been taken either from Argelander* or Johnson, where possible; if not one of these, Groombridge has been employed, or the *Histoire Céleste*.

Mädler's systematic corrections, referred to above, are, so far as we shall want them: —

* Argelander's *Uranometria Nova* has been used, in preference to other authorities, for magnitudes.

Dec.	M.—Pi.*	M.—Gr.	M.—Str.	M.—Arg	M.—T.	M.—R.	M.—Ai.	M.—J.
70°	+0″.5	+0″.7	—0″.1	—0″.7	+0″.1	—2″.0	—0″.2	—0″.6
60	+0.3	+0.2	—0.2	—0.4	+0.2	—1.4	—0.3	—1.2
50	+0.1	—0.1	—0.4	—0.4	+0.1	—0.9	—0.6	—1.6
40	—0.3	+0.3	+0.5	—0.1	+0.6	—0.2	+0.4	—1.5
30	—1.0		+0.4	0.0	+0.5	+0.4	+0.5	—1.2
20	—1.6		+0.2	—0.2	+0.3	+0.6	+0.2	—1.2

The discussion of *α* Cygni was taken from Mädler's larger work,† introducing the systematic corrections given later.

For the Catalogues *Ja.*, *J.* 2, and *Ai.* 2, the following investigations were made.

A direct comparison of *Ja.* with *M.* gave:—

M. Dec.	M.—Ja.	
35°	—0″.06	10 comp.
45	—0.20	8 "
55	—0.28	11 "
65	—0.08	25 "

The value *M.*—*Ja.* = —0″.2 was used throughout.

The Catalogue *J.* 2 furnishes positions differing from the former volumes of the Radcliffe Observations by corrections given in Vol. XV. of that work, and repeated subsequently; provided, however, as I have done, we apply the correction for difference between direct and reflected observations to the positions of the Special Catalogues for 1854–1857; this same correction having been already applied to the "Catalogue of Remarkable Objects," in the volume for 1856.

Below 40° of declination, however, Mädler's systematic corrections are derived from much less material than for the circumpolar regions. We have, correcting Mädler by Johnson's table in Vol. XV. of the Radcliffe Observations:—

Dec.	M.—J. 2.	Dec.	M.—J. 2.
72°	+0″.53	54°	—0″.15
66	+0.41	48	—0.20
60	+0.08		

Below 48° the value *M.*—*J.* 2 = —0″.20 was used throughout, from the following considerations. Between 22° and 40°,—

M.—J. 2 = —0″.18 30 comp.

* I regret that Piazzi's Catalogue was not at my disposal. A few positions for 1800.0 I owe to Prof. Brünnow's kindness.

† "Untersuchungen über die Fix-stern-Systeme," Mitau, 1847, fol.

Between 22° and 30°, —

A. — J. 2 =	— 0″.19	(Direct comp.)
M. — A. (mean)	— 0″.08	(Mädler.)

whence

M. — J. 2	— 0″.27

A direct comparison between *M.* and *J.* 2 gave also,

Dec.	M. — J. 2.	
40° — 50°	— 0″.4	17 stars.
50 — 70	+ 0.1	9 "

agreeing as well with the above table as was to be expected.

The new Transit Circle at Greenwich seems to give results within our limits pretty nearly in accordance with the Mural Circles used during the years 1812 - 1851. At least we find: —

	M. — Greenwich Obs. 1857.	No. Comp.
30° — 40°	+ 0″.95	12
40 — 50	— 0.04	16
50 — 60	— 0.51	11

The first number differs slightly from the corresponding mean from Mädler's table; the others are in almost perfect accordance. I have therefore employed the same systematic correction for *Ai.* 2 as for *Ai.*

A cursory examination of Oudemans's table (Diss. Astro., p. 112) showed that the few declinations taken thence might be used without sensible error, as harmonizing with Mädler's positions. To these positions, weights varying from 2 to 6, according to the number of observations, have been assigned. The probable error of the assumption *M.* = *Ou.* is likely to be quite equal to that of a position given by Oudemans.

Wolfers, in the *Tabulæ Reductionum*, shows that for the fundamental stars south of 49° included in his Catalogue, Pond's positions corrected by Olufsen agree with the determinations given in the *Tabulæ*; Mädler's positions, which are reduced to Pond, after correcting the latter in a somewhat similar manner, will be found also nearly accordant.

The magnitudes in parentheses are derived from Catalogues where no information is given regarding the method pursued in obtaining them.

The Right Ascensions to seconds have been taken from the British Association Catalogue. The initials of the Catalogues have already been explained. The numbers in parentheses in the column "No. Obs." refer to the differential observations of Oudemans. The last two columns contain the Annual Precession for 1859 and Proper Motion in Declination; the latter taken, in order of preference, from Mädler and the British Association Catalogue.

B. A. C.	Mag.	α 1859.0.	Annual Variation.	Authority.	Mean Year.	No. Obs.	δ 1859.0.	Systematic Correction.	Precession.	Proper Motion.
		h m s	s				° ′ ″	″	″	″
13	7	0 2 44	+ 3.1	Gr.		4	45 36 21.9	+ 0.1	+ 20.05	
				Str.	1824	6	22.7	+ 0.0		
				J.	1846	4	23.6	— 1.6		
				Ja.	1850	4	24.3	— 0.2		
				Ad.			45 36 22.8			
16	5.6	0 3 0	+ 3.1	M.		45	45 17 15.6		+ 20.05	+ 0.01
28	6	0 6 12	+ 3.1	M.		24	40 15 27.5		+ 20.05	— 0.12
60	6	0 11 17	+ 3.1	M.		32	43 0 28.7		+ 20.03	+ 0.01
				Ai. 2		2	27.9	+ 0.1		
				Ad.			43 0 28.6			
67	6	0 13 42	+ 3.1	M.		24	37 11 14.4		+ 20.02	— 0.06
78	6.7	0 16 36	+ 3.2	Gr.		10	43 28 59.8	+ 0.2	+ 20.01	
				R.		1	59.0	— 0.5		
				Ai.	1842	21	58.3	+ 0.1		
				J.	1844	4	59.8	— 1.5		
				Ja.	1850	4	58.8	— 0.2		
				Ad.			43 28 57.7			
100	6	0 20 39	+ 3.2	Gr.		6	43 36 52.8	+ 0.2	+ 19.98	— 0.01
				T.		4	51.0	+ 0.4		
				J.	1844	4	53.6	— 1.5		
				Ad.			43 36 51.7			
121	5	0 24 1	+ 3.3	M.		51	53 44 36.0		+ 19.94	— 0.01
152	6	0 29 7	+ 3.2	Gr.		7	43 42 35.9	+ 0.2	+ 19.90	+ 0.01
				T.		4	35.4	+ 0.4		
				R.	1846	1	37.3	— 0.5		
				J.	1844	3	38.6	— 1.5		
				Ai. 2	1855	4	37.1	0.0		
				Ad.			43 42 37.3			
155	4	0 29 21	+ 3.2	M.		46	32 56 33.8		+ 19.89	+ 0.01
173	5	0 33 30	+ 3.2	M.		35	38 41 3.1		+ 19.84	0.00
				J. 2	1856	3	3.1	— 0.2		
				Ad.			38 41 3.1			
182	7	0 34 26	+ 3.4	M.		24	57 58 45.4		+ 19.83	— 0.01
189	6	0 35 41	+ 3.3	M.		54	46 15 9.1		+ 19.81	— 0.03
197	6	0 36 37	+ 3.3	M.		3	47 5 27.7		+ 19.80	+ 0.04
224	7	0 41 36	+ 3.2	L.	1801	1	27 57 0.7	— 1.5	+ 19.72	
				Ja.	1850	4	56 59.4	— 0.2		
				Ad.			27 56 59.2			
227	4.5	0 42 3	+ 3.3	M.		65	40 18 38.2		+ 19.72	— 0.01
232	6.7	0 42 54	+ 3.4	Gr.		6	50 44 20.1	— 0.1	+ 19.70	— 0.08
				T.		4	20.6	+ 0.1		
				J.	1847	6	24.5	— 1.6		
				Ou.	1849	(17)	21.9	+ 0.0		
				J. 2	1857	1	21.8	— 0.2		
				Ad.			50 44 23.1			
235	6.7	0 43 33	+ 3.4	Gr.		6	50 48 12.7	— 0.1	+ 19.69	— 0.06
				T.		3	12.4	+ 0.1		
				J.	1846	5	14.8	— 1.6		
				Ou.	1849	(16)	13.1	+ 0.0		
				Ad.			50 48 13.3			
244	6.5	0 46 39	+ 3.5	M.		25	58 12 29.7		+ 19.64	— 0.10
				J. 2	1857	3	30.2	+ 0.0		
				Ad.			58 12 29.8			
253	2	0 48 13	+ 3.5	M.		228	59 57 8.0		+ 19.61	— 0.02
				J. 2	1857	3	7.2	+ 0.1		
				Ai. 2	1856	19	7.7	— 0.3		
				Ad.			59 57 7.9			
255	6	0 48 19	+ 3.5	Gr.		7	59 35 54.3	+ 0.2	+ 19.61	

B. A. C.	Mag.	α 1859.0.	Annual Variation.	Authority.	Mean Year.	No. Obs.	δ 1859.0.	Systematic Correction.	Precession.	Proper Motion.
		h m s	s				° ′ ″	″		
255	6	0 48 19	+ 3.5	R.		6	59 35 56.3	— 1.4		
				J.	1848	4	55.6	— 1.2		
				Ja.	1850	4	54.9	— 0.2		
				Ad.			59 35 54.6			
256	6	0 48 24	+ 3.2	M.		24	26 26 39.1		+ 19.61	+ 0.01
282	6	0 54 57	+ 3.6	Gr.		6	60 18 56.3	+ 0.2	+ 19.48	
				J.	1848	4	57.7	— 1.2		
				Ja.	1850	4	57.5	— 0.2		
				Ad.			60 18 56.9			
285	5	0 55 6	+ 3.3	M.		29	31 2 47.0		+ 19.48	— 0.03
299	(6)	0 56 45	+ 3.2	L.	1795	1	28 54 27.7	— 1.5	+ 19.44	
				R.		2	24.2	+ 0.4		
				Ja.	1850	6	21.0	— 0.2		
				Ad.			28 54 20.8			
302	7	0 57 30	+ 3.7	Gr.		6	62 0 22.0	+ 0.4	+ 19.43	
				J.	1845	4	22.5	— 1.0		
				Ja.	1850	4	22.0	— 0.2		
				Ad.			62 0 21.3			
330	4.5	1 1 20	+ 3.4	M.		56	46 29 19.8		+ 19.34	— 0.01
352	6.7	1 4 26	+ 3.4	Gr.		6	44 35 9.4	+ 0.2	+ 19.27	— 0.05
				T.		4	9.7	+ 0.3		
				Ai.	1844	5	11.2	— 0.1		
				J.	1844	3	11.8	— 1.5		
				J. 2	1857	2	10.5	— 0.2		
				Ad.			44 35 11.1			
377	7	1 8 24	+ 3.4	Gr.		5	42 11 41.7	+ 0.3	+ 19.17	
				J.	1845	4	43.4	— 1.5		
				Ja.	1851	3	40.3	— 0.2		
				Ad.			42 11 41.2			
404	5	1 14 3	+ 3.5	M.		56	44 47 17.8		+ 19.02	— 0.03
				Ai. 2	1856	2	19.1	+ 0.0		
				Ad.			44 47 17.9			
432	5	1 19 14	+ 3.6	M.		44	44 40 37.7		+ 18.87	— 0.10
				J. 2	1857	5	36.1	— 0.2		
				Ad.			44 40 37.4			
441	6	1 21 40	+ 3.6	M.		38	46 16 41.2		+ 18.80	— 0.06
465	6	1 26 9	+ 3.4	Arg.	1830	6	36 30 46.8	— 0.3	+ 18.65	+ 0.05
				T.		4	45.2	+ 0.7		
				Ad.			36 30 46.2			
480	4.5	1 28 32	+ 3.5	M.		67	40 41 55.0		+ 18.58	— 0.38
				J. 2	1858	1	56.6	— 0.2		
				Ad.			40 41 55.0			
522	4	1 34 51	+ 3.7	M.		93	49 58 35.6		+ 18.36	— 0.03
				Ai. 2	1850	6	36.2	— 0.6		
				J. 2	1857	1	34.7	— 0.2		
				Ad.			49 58 35.6			
558	6	1 42 45	+ 3.9	M.		39	54 26 48.2		+ 18.07	— 0.06
560	6	1 43 13	+ 3.8	M.		55	50 5 36.0		+ 18.05	— 0.04
562	6.7	1 43 51	+ 3.8	Lal.	1799	2	50 46 35.5		+ 18.03	
				Ja.	1850	4	34.1	— 0.2		
				Ad.			50 46 33.9			
566	6	1 44 51	+ 3.6	M.		26	40 1 55.2		+ 17.99	— 0.01
575	6.7	1 46 25	+ 3.6	M.		5	40 0 35.6		+ 17.93	— 0.03
				Ja.		3	33.6	— 0.2		
				Ad.			40 0 34.5			
576	6	1 46 38	+ 3.5	Pi.			36 25 64.7	— 0.6	+ 17.92	— 0.05
				T.		3	59.8	+ 0.7		
				Ad.			36 25 58.0			

B. A. C.	Mag.	α 1859.0.	Annual Variation.	Authority.	Mean Year.	No. Obs.	δ 1859.0.	Systematic Correction.	Precession.	Proper Motion.
		h m s	s				° ′ ″	″	″	″
579	6	1 47 35	+3.5	M.		26	36 35 3.6		+17.88	0.00
580	6	1 47 47	+3.5	M.		23	36 33 29.4		+17.87	+0.01
				J. 2	1857	2	30.7	—0.2		
				Ad.			36 33 29.6			
614	5.6	1 52 56	+3.9	M.		44	53 48 12.0		+17.67	—0.03
649	5	2 0 0	+3.6	M.		17	37 11 17.1		+17.37	—0.05
				J. 2	1857	1	20.3	—0.2		
				Ad.			37 11 17.4			
656	3	2 1 10	+3.5	M.		105	34 19 6.2		+17.31	—0.03
				J. 2	1855	3	6.6	—0.2		
				Ai. 2	1853	11	7.1	+0.6		
				Ad.			34 19 6.5			
658	7	2 1 42	+4.1	M.		42	56 58 37.9		+17.29	+0.02
675	6.5	2 4 12	+3.5	M.		24	29 38 24.9		+17.18	—0.06
				J. 2	1856	3	26.8	—0.2		
				Ad.			29 38 25.2			
690	7	2 7 2	+4.1	Gr.		6	56 23 50.6	+0.0	+17.05	+0.11
				T.		4	47.4	+0.1		
				Ai.	1838	9	48.7	—0.5		
				J.	1846	3	48.1	—1.4		
				Ad.			56 23 46.2			
695	6.7	2 8 3	+4.2	M.		20	57 14 32.8		+17.01	—0.03
697	6.5	2 8 27	+3.6	M.		33	33 34 36.7		+16.99	—0.23
				J. 2	1856	4	37.6	—0.2		
				Ad.			33 34 36.8			
705	6.7	2 10 12	+3.9	Gr.		6	48 17 54.5	+0.0	+16.90	+0.08
				R.		1	57.6	—0.8		
				J.	1847	4	57.9	—1.6		
				Ad.			48 17 56.9			
727	6	2 14 5	+3.7	Gr.		6	40 45 17.3	+0.3	+16.72	—0.09
				T.		4	20.3	+0.6		
				J.	1844	4	18.6	—1.5		
				Ad.			40 45 18.5			
735	5	2 16 14	+4.0	M.		52	49 38 15.9		+16.61	—0.04
749	7	2 18 25	+4.0	M.		23	49 56 10.8		+16.51	—0.12
				J. 2	1857	3	11.8	—0.2		
				Ad.			49 56 11.0			
761	6.7	2 21 13	+3.7	Gr.		6	38 30 21.4	+0.2	+16.37	
				R.	1850	1	21.7	—0.1		
				Ai.	1844	5	21.5	+0.5		
				J.	1848	3	21.9	—1.4		
				Ja.	1850	5	20.5	—0.2		
				Ad.			38 30 21.0			
806	7.8	2 30 34	+4.1	Gr.		6	52 11 36.4	—0.2	+15.88	+0.02
				T.		4	35.8	+0.0		
				R.		5	35.9	—1.0		
				J.	1845	3	37.3	—1.5		
				Ad.			52 11 35.1			
819	6	2 33 4	+4.2	Gr.		6	52 55 19.2		+15.75	
				J.	1844	3	17.7	—1.5		
				Ad.			52 55 14.9			
871	5.4	2 41 42	+3.8	M.		36	37 44 7.1		+15.27	—0.09
				J. 2	1857	5	7.9	—0.2		
				Ad.			37 44 7.2			
888	6	2 44 49	+3.8	M.		25	37 45 36.9		+15.09	—0.07
912	5	2 49 45	+3.8	M.		40	39 5 44.1		+14.80	—0.04
918	5	2 50 51	+4.2	Gr.		6	51 47 16.6	—0.2	+14.73	+0.05
				Str.	1824	6	51 47 16.6	—0.4		

B. A. C.	Mag.	α 1859.0.	Annual Variation.	Authority.	Mean Year.	No. Obs.	δ 1859.0.	Systematic Correction.	Precession.	Proper Motion.
		h m s	s				° ′ ″	″	″	″
918	5	2 50 51	+ 4.2	T.		4	51 47 15.5	+ 0.0		
				R.		5	13.8	— 1.0		
				J.	1847	4	16.8	— 1.5		
				Ad.			51 47 14.9			
947	3	2 54 36	+ 4.3	M.		73	52 57 2.2		+ 14.51	— 0.02
				Ai. 2	1855	5	2.7	— 0.6		
				Ad.			52 57 2.2			
953	4	2 56 9	+ 3.8	M.		51	38 17 27.6		+ 14.42	— 0.10
				Ai. 2	1855	5	26.9	+ 0.5		
				Ad.			38 17 27.6			
962	4	2 58 55	+ 4.3	Gr.		6	49 4 18.7	— 0.1	+ 14.25	+ 0.00
				Arg.	1830	24	17.9	— 0.4		
				T.		10	18.4	+ 0.1		
				Ai.	1845	9	16.9	— 0.6		
				J.	1845	3	17.5	— 1.6		
				J. 2	1856	3	14.4	— 0.2		
				Ad.			49 4 15.7			
983	6.7	3 2 51	+ 3.9	Gr.		5	41 50 24.8	+ 0.3	+ 14.00	
				R.		1	25.0	— 0.4		
				J.	1843	3	25.7	— 1.5		
				Ja.	1850	4	24.1	— 0.2		
				Ad.			41 50 23.7			
993	6	3 5 36	+ 4.0	Gr.		6	41 58 24.1	+ 0.3	+ 13.83	+ 0.02
				T.		4	24.3	+ 0.5		
				R.		1	25.5	— 0.4		
				J.	1845	3	27.0	— 1.5		
				Ad.			41 58 25.8			
1030	6.5	3 12 28	+ 5.1	Gr.		6	64 4 38.2	+ 0.5	+ 13.39	— 0.09
				T.		4	33.5	+ 0.3		
				R.	1850	1	39.5	— 1.6		
				J.	1845	4	39.4	— 0.9		
				Ad.			64 4 38.4			
1040	6	3 13 44	+ 3.6	M.		21	27 5 52.1		+ 13.30	— 0.03
1066	5	3 19 18	+ 4.3	M.		34	49 1 0.1		+ 12.94	— 0.05
1083	6	3 22 41	+ 4.1	M.		19	45 34 31.1		+ 12.71	— 0.07
1105	6.7	3 28 28	+ 4.0	Gr.		5	42 6 54.6	+ 0.3	+ 12.32	
				R.		2	50.5	— 0.4		
				J.	1844	3	55.2	— 1.5		
				Ja.	1850	3	53.5	— 0.2		
				Ad.			42 6 52.3			
1139	4	3 35 37	+ 4.0	M.		62	42 7 45.8		+ 11.81	— 0.02
1142	6	3 36 8	+ 4.2	Gr.		6	45 14 8.1	+ 0.1	+ 11.78	
				J.	1845	3	9.9	— 1.6		
				Ja.	1850	4	7.4	— 0.2		
				Ad.			45 14 7.8			
1172	6	3 40 16	+ 4.1	Gr.		6	44 31 61.0	+ 0.2	+ 11.49	
				J.	1844	2	60.3	— 1.5		
				Ja.	1850	4	60.7	— 0.2		
				Ad.			44 31 59.1			
1252	7	3 55 54	+ 4.3	Gr.		6	46 32 19.5	+ 0.1	+ 10.33	+ 0.02
				T.		4	17.0	+ 0.2		
				R.		2	15.3	— 0.7		
				J.	1846	4	18.6	— 1.6		
				Ad.			46 32 15.5			
1264	(6)	3 58 11	+ 4.0	Pi.			37 42 11.4	— 0.5	+ 10.17	— 0.25
				Arg.	1830	9	3.5	+ 0.0		
				T.		4	37 42 2.6	+ 0.7		
				J. 2.	1857	1	37 41 56.4	— 0.2		

B. A. C.	Mag.	α 1850.0.	Annual Variation.	Authority.	Mean Year.	No. Obs.	δ 1850.0.	Systematic Correction.	Precession.	Proper Motion.
		h m s	s				° ′ ″	″	″	″
1264	(6)	3 58 11	+ 4.0	Ad.			37 41 55.9			
1269	6	3 59 13	+ 4.0	M.		30	37 40 0.4		+ 10.09	− 0.19
				J. 2	1856	2	0.6	− 0.2		
				Ad.			37 40 0.4			
1293	5	4 5 43	+ 4.6	Gr.		11	53 15 11.2	− 0.1	+ 9.59	− 0.06
				T.		4	10.0	+ 0.0		
				J.	1844	4	11.2	− 1.5		
				Ad.			53 15 9.1			
1307	6.7	4 8 38	+ 4.5	Gr.		6	49 42 3.8	− 0.1	+ 9.37	
				J.	1845	4	3.0	− 1.6		
				Ou.	1849	(2)	3.1	+ 0.0		
				Ja.	1850	4	0.6	− 0.2		
				Ad.			49 42 0.6			
1320	6.7	4 10 30	+ 4.1	Gr.		6	41 27 47.5	+ 0.3	+ 9.22	+ 0.04
				T.		4	47.4	+ 0.5		
				R.		4	46.9	− 0.4		
				J.	1845	3	49.1	− 1.5		
				Ad.			41 27 47.2			
1382	6	4 20 53	+ 4.7	M.		38	53 35 56.4		+ 8.41	− 0.02
1398	6	4 23 30	+ 4.2	M.		21	42 45 30.9		+ 8.20	+ 0.01
				J. 2	1857	1	33.2	− 0.2		
				Ai. 2	1855	1	27.5	+ 0.2		
				Ad.			42 45 30.8			
1476	6	4 40 25	+ 4.0	M.		29	37 14 6.2		+ 6.82	+ 0.07
1477	6	4 40 34	+ 4.5	Gr.		5	48 29 35.9	+ 0.0	+ 6.81	0.00
				T.		4	33.9	+ 0.1		
				J.	1843	3	34.7	− 1.6		
				Ou.	1849	(20)	33.3	+ 0.0		
				Ad.			48 29 32.5			
1504	5	4 46 0	+ 4.8	M.		56	53 31 15.0		+ 6.36	− 0.02
1524	7	4 48 33	+ 4.8	M.		24	52 55 58.3		+ 6.15	− 0.06
1530	6	4 49 41	+ 4.1	M.		46	37 40 21.9		+ 6.06	− 0.10
1534	6.7	4 50 37	+ 4.1	M.		22	39 10 35.9		+ 5.98	+ 0.01
1535	6.7	4 50 41	+ 4.1	M.		22	39 26 12.4		+ 5.97	+ 0.01
1554	5	4 55 38	+ 4.7	M.		40	51 24 18.3		+ 5.56	− 0.18
				J. 2	1858	4	18.8	− 0.1		
				Ad.			51 24 18.4			
1622	6	5 7 18	+ 5.1	Gr.		6	57 57 37.5	+ 0.1	+ 4.57	− 0.03
				T.		4	34.2	+ 0.1		
				J.	1846	4	35.9	− 1.3		
				Ad.			57 57 32.9			
1627	5	5 8 55	+ 3.9	M.		17	33 13 13.0		+ 4.43	− 0.16
				J. 2	1857	1	13.2	− 0.2		
				Ad.			33 13 13.0			
1631	5	5 9 13	+ 4.2	M.		67	39 58 9.3		+ 4.41	− 0.65
				J. 2	1857	2	9.0	− 0.2		
				Ad.			39 58 9.3			
1642	6.5	5 11 23	+ 5.1	M.		33	57 24 5.4		+ 4.22	− 0.05
1645	6.5	5 11 50	+ 4.2	M.		27	41 39 32.2		+ 4.18	− 0.05
1723	5	5 23 33	+ 3.9	M.		42	32 5 1.1		+ 3.18	+ 0.02
				Ai. 2	1856	3	4 59.5	+ 0.6		
				Ad.			5 1.0			
1804	6.5	5 35 0	+ 4.7	M.		48	49 45 32.5		+ 2.18	− 0.03
				J. 2	1856	3	32.7	− 0.2		
				Ou.	1849	(18)	33.3	0.0		
				Ad.			49 45 32.5			
1830	5	5 39 24	+ 4.2	M.		25	39 7 41.0		+ 1.80	− 0.04
1844	5	5 41 26	+ 4.1	M.		27	37 15 37.0		+ 1.62	− 0.04

B. A. C.	Mag.	α 1859.0.	Annual Variation.	Authority.	Mean Year.	No. Obs.	δ 1859.0.	Systematic Correction.	Precession.	Proper Motion.
		h m s	s				° ′ ″	″	″	″
1845	4	5 41 43	+ 4.2	M.		47	39 6 9.5		+ 1.60	+ 0.05
1849	5.6	5 42 20	+ 5.4	M.		85	59 51 0.5		+ 1.54	— 0.03
				Ai. 2	1857	19	50 59.8	— 0.3		
				Ad.			59 51 0.2			
1854	5	5 43 2	+ 5.0	M.		37	55 40 5.1		+ 1.48	— 0.02
1885	4.5	5 47 55	+ 4.9	M.		159	54 16 4.2		+ 1.06	— 0.14
				Ai. 2	1853	1	5.2	— 0.6		
				J. 2	1857	1	4.5	— 0.2		
				Ad.			54 16 4.2			
1895	2	5 49 11	+ 4.4	M.		315	44 55 41.2		+ 0.95	— 0.01
				Ai. 2	1855	7	40.8	— 0.1		
				Ad.			44 55 41.2			
1897	5	5 49 28	+ 4.5	Gr.		11	45 55 8.9	+ 0.1	+ 0.92	— 0.02
				T.		5	9.3	+ 0.2		
				J.	1847	3	8.8	— 1.6		
				Ad.			45 55 7.7			
1900	3	5 50 6	+ 4.1	M.		45	37 11 53.2		+ 0.87	— 0.11
				Ai. 2	1855	10	53.6	+ 0.6		
				J. 2	1855	2	54.3	— 0.2		
				Ad.			37 11 53.5			
1902	6	5 50 17	+ 4.5	M.		27	47 53 15.2		+ 0.85	— 0.04
1914	6	5 51 51	+ 4.7	Gr.		5	49 53 56.4	— 0.1	+ 0.71	[+ 0.10]
				T.		4	(54 5.4)			
				J.	1845	3	53 55.3	— 1.6		
				Ad.			49 53 52.7			
1923	6	5 53 8	+ 4.3	M.		43	42 54 39.2		+ 0.60	— 0.16
				J. 2	1857	4	39.4	— 0.2		
				Ad.			42 54 39.2			
1943	6	5 57 32	+ 5.3	M.		46	58 56 51.0		+ 0.21	+ 0.02
1963	6.7	6 0 49	+ 4.6	M.		35	48 44 3.7		— 0.07	— 0.04
				J. 2	1856	4	2.4	— 0.2		
				Ad.			48 44 3.4			
1979	6	6 3 0	+ 5.4	M.		41	60 1 53.6		— 0.26	— 0.05
2001	5.4	6 6 24	+ 3.8	M.		83	29 32 45.3		— 0.56	— 0.23
				Ai. 2	1856	10	44.8	+ 0.5		
				J. 2	1855	8	44.4	— 0.2		
				Ad.			29 32 45.1			
2007	5.4	6 7 11	+ 5.3	M.		87	59 3 20.4		— 0.63	+ 0.01
				J. 2		4	20.3	+ 0.1		
				Ad.			59 3 20.4			
2008	7	6 7 4	+ 4.5	M.		18	46 27 55.6		— 0.62	— 0.01
2010	6.7	6 7 46	+ 4.5	M.		26	46 24 36.3		— 0.68	— 0.15
				J. 2	1857	3	35.7	— 0.2		
				Ad.			46 24 36.1			
2044	5	6 14 2	+ 4.6	M.		80	49 21 17.0		— 1.23	+ 0.05
				Ou.		(18)	16.9			
				Ad.			49 21 17.0			
2046	6	6 14 32	+ 5.1	Gr.		5	56 21 15.1	0.0	— 1.27	
				J.	1848	4	17.0	— 1.4		
				Ja.	1850	4	16.1	— 0.2		
				Ad.			56 21 15.9			
2128	6	6 25 39	+ 5.1	M.		25	56 57 56.9		— 2.24	+ 0.04
2133	6.5	6 26 19	+ 3.8	M.		24	28 7 41.5		— 2.30	0.00
				Ai. 2	1857	3	40.6	+ 0.4		
				Ad.			28 7 41.4			
2139	6	6 26 51	+ 4.1	Gr.		6	38 33 17.6		— 2.34	
				J.	1851	4	19.8	— 1.4		
				Ja.	1850	4	38 33 15.8	— 0.2		

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2139	6	6 26 51	+ 4.1	Ad.			38 33 17.5			
2159	5	6 29 16	+ 4.3	M.		27	42 36 29.2		− 2.55	− 0.04
2161	6	6 29 26	+ 3.8	M.		18	29 6 3.0		− 2.57	− 0.01
2170	6	6 30 40	+ 3.8	M.		26	28 22 58.0		− 2.68	− 0.06
				Ai. 2	1857	1	59.7	+ 0.4		
				Ad.			28 22 58.1			
2182	5	6 32 49	+ 4.4	M.		65	44 39 18.6		− 2.86	− 0.02
2187	5	6 33 46	+ 5.3	M..		46	59 34 42.0		− 2.94	0.00
				J. 2	1855	4	41.8	+ 0.1		
				Ad.			59 34 42.0			
2192	6	6 34 49	+ 5.2	M.		27	57 18 33.7		− 3.03	− 0.08
				J. 2	1857	1	35.6	− 0.1		
				Ad.			33.9			
2201	6	6 36 55	+ 4.6	M.		43	48 55 59.4		− 3.22	− 0.01
				Ou.	1849	(17)	59.8	+ 0.0		
				Ad.			48 55 59.5			
2223	5	6 40 47	+ 4.2	M.		34	41 56 32.6		− 3.55	− 0.12
				Ai. 2	1856	2	32.5	+ 0.3		
				J. 2	1856	2	35.1	− 0.2		
				Ad.			41 56 32.9			
2237	3.4	6 43 30	+ 4.0	M.		50	34 7 37.2		− 3.78	− 0.03
2239	6.7	6 43 34	+ 4.1	M.		29	38 36 32.9		− 3.79	− 0.20
				J. 2	1857	1	36.0	− 0.2		
				Ad.			38 36 33.1			
2241	6.7	6 44 17	+ 4.1	M.		24	38 40 24.0		− 3.85	− 0.01
2248	5	6 45 3	+ 5.2	M.		89	58 36 4.6		− 3.92	− 0.17
				J. 2	1857	4	5.2	+ 0.0		
				Ad.			58 36 4.7			
2261	5	6 47 19	+ 4.4	M.		31	45 16 20.3		− 4.11	− 0.01
2338	5	7 1 57	+ 4.1	M.		65	39 32 46.6		− 5.35	+ 0.02
2340	5.4	7 2 10	+ 3.8	M.		78	30 28 20.0		− 5.37	− 0.04
				Ai. 2	1854	1	19.2	+ 0.5		
				J. 2	1856	5	21.0	− 0.2		
				Ad.			30 28 20.1			
2361	6	7 5 21	+ 4.5	Gr.		6	47 29 16.5	+ 0.0	− 5.65	
				J.	1848	5	10.9	− 1.6		
				Ja.	1850	3	9.7	− 0.2		
				Ad.			47 29 7.4			
2367	6	7 6 29	+ 4.7	Gr.		6	52 22 33.3	− 0.2	− 5.74	
				J.	1847	7	30.4	− 1.5		
				Ja.	1850	4	27.9	− 0.2		
				Ad.			52 22 27.3			
2379	6	7 7 48	+ 4.6	J.	1848	4	49 42 41.5	− 1.6	− 5.85	
				Ja.	1850	4	42 39.8	− 0.2		
				Ad.			42 39.8			
2381	6	7 8 14	+ 4.2	M.		58	41 7 45.9		− 5.88	+ 0.01
				Ai. 2	1856	4	45.8	+ 0.4		
				Ad.			41 7 45.9			
2407	5	7 11 21	+ 4.9	M.		44	55 32 30.1		− 6.14	− 0.06
2429	6	7 14 22	+ 4.2	M.		26	40 56 22.3		− 6.39	− 0.02
2441	5	7 16 4	+ 4.6	M.		28	49 29 10.3		− 6.54	− 0.08
2442	4	7 16 58	+ 3.7	M.		97	28 4 28.1		− 6.61	− 0.09
				Ai. 2	1856	10	27.5	+ 0.4		
				J. 2	1857	4	29.2	− 0.2		
				Ad.			28 4 28.1			
2459	6	7 19 12	+ 4.6	M.		42	49 57 31.6		− 6.79	− 0.09
				J. 2	1857	2	31.1	− 0.2		
				Ou.	1849	(10)	49 57 32.0	0.0		

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		h m s	s				° ′ ″			
2459	6	7 19 12	+ 4.6	Ad.			49 57 31.6			
2467	5	7 20 33	+ 3.8	M.		28	28 24 16.9		— 6.90	— 0.06
				Ai. 2	1855	4	17.2	+ 0.4		
				Ad.			28 24 17.0			
2469	5	7 21 2	+ 3.7	M.		15	28 12 12.5		— 6.94	— 0.01
				Ai. 2	1855	4	10.5	+ 0.4		
				Ad.			28 12 12.0			
2488	6	7 26 16	+ 4.4	J.	1847	4	46 29 13.3	— 1.6	— 7.37	
				Ja.	1850	5	11.5	— 0.2		
				Ad.			46 29 11.5			
2493	4.5	7 27 14	+ 3.7	M.		53	27 12 19.9		— 7.45	— 0.10
				Ai. 2	1854	1	19.6	+ 0.4		
				J. 2	1857	5	20.4	— 0.2		
				Ad.			20.1			
2516	5	7 31 3	+ 5.1	M.		54	59 2 5.4		— 7.76	— 0.08
2540	5	7 34 30	+ 3.8	M.		36	29 13 15.4		— 8.04	— 0.24
				J. 2.	1855	3	15.6	— 0.2		
				Ad.			29 13 15.4			
2606	6.7	7 44 13	+ 4.4	M.		34	47 44 47.2		— 8.81	— 0.02
				Ou.	1849	(3)	46.4	+ 0.0		
				Ad.			47 44 47.1			
2609	6	7 44 26	+ 4.4	M.		47	47 55 31.9		— 8.83	— 0.03
				Ou.	1849	(5)	32.3	+ 0.0		
				Ad.			47 55 31.9			
2638	6.7	7 48 21	+ 4.2	Gr.		6	44 20 58.5	+ 0.2	— 9.13	
				J.	1844	4	21 0.1	— 1.5		
				Ja.	1850	4	20 58.7	— 0.2		
				Ad.			44 20 58.5			
2672	5	7 54 51	+ 3.7	M.		45	28 11 9.8		— 9.63	— 0.04
				Ai. 2	1855	43	9.9	+ 0.4		
				J. 2	1856	4	11.9	— 0.2		
				Ad.			28 11 10.2			
2697	5.4	7 57 50	+ 4.6	M.		85	51 54 31.4		— 9.86	0.00
				Ou.	1849	(8)	31.2	+ 0.0		
				Ad.			51 54 31.4			
2732	6.5	8 2 34	+ 4.8	Gr.		6	56 52 14.4	+ 0.0	— 10.22	+ 0.02
				T.		4	13.8	+ 0.1		
				R.		6	15.2	— 1.2		
				Ai.	1840	7	13.5	— 0.5		
				J.	1843	5	15.4	— 1.4		
				Ad.			56 52 13.5			
2747	6	8 4 24	+ 3.7	M.		41	30 4 32.4		— 10.36	— 0.02
2792	6	8 13 6	+ 4.6	Gr.		6	53 40 16.8	— 0.1	— 11.00	— 0.04
				T.	1835	4	12.8	0.0		
				Ai.	1843	5	12.8	— 0.6		
				J.	1844	5	13.2	— 1.5		
				Ad.			53 40 9.8			
2819	3.4	8 18 31	+ 5.1	M.		272	61 11 4.9		— 11.40	— 0.14
				J. 2	1857	3	4.5	+ 0.1		
				Ad.			61 11 4.9			
2871	6	8 25 40	+ 3.9	M.		19	36 54 0.8		— 11.91	— 0.02
2887	6	8 27 49	+ 4.5	Gr.		6	53 53 19.9	— 0.1	— 12.05	
				R.		4	20.8	— 1.1		
				Ai.	1845	5	19.4	— 0.6		
				J.	1844	4	19.9	— 1.5		
				Ja.	1850	3	17.8	— 0.2		
				Ad.			53 53 18.1			
2892	6	8 28 49	+ 4.5	Gr.		5	53 12 7.1	— 0.1	— 12.13	+ 0.01

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		h m s	s				° ′ ″	″	″	″
2892	6	8 28 49	+ 4.5	T.		4	53 12 6.0	0.0		
				J.	1845	4	8.2	— 1.5		
				Ad.			53 12 6.2			
2909	6	8 31 15	+ 4.2	M.		35	46 19 29.3		— 12.29	+ 0.07
3000	6.7	8 43 58	+ 3.6	M.		16	28 47 7.6		— 13.15	— 0.01
				J. 2	1855	4	9.1	— 0.2		
				Ad.			28 47 8.0			
3025	6	8 47 16	+ 4.1	Gr.		6	46 10 10.6	+ 0.1	— 13.37	+ 0.04
				T.		4	10.1	+ 0.2		
				R.		1	9.4	— 0.7		
				J.	1848	5	10.6	— 1.6		
				Ad.			46 10 8.7			
3027	6	8 47 21	+ 3.9	Gr.		6	40 44 22.0	+ 0.3	— 13.38	
				R.		2	18.7	— 0.2		
				J.	1844	4	20.7	— 1.5		
				Ja.	1850	4	19.4	— 0.2		
				Ad.			40 44 17.9			
3046	(6)	8 49 24	+ 3.7	M.		26	30 46 21.2		— 13.51	+ 0.03
3059	4	8 51 28	+ 3.9	M.		60	42 20 17.1		— 13.64	— 0.28
				Ai. 2	1856	1	16.9	+ 0.3		
				J. 2	1856	7	18.1	— 0.2		
				Ad.			42 20 17.2			
3069	6	8 53 24	+ 3.6	M.		23	28 27 18.7		— 13.77	— 0.08
3072	6	8 53 39	+ 4.4	Gr.		6	54 50 10.2		— 13.78	
				R.		3	10.4	— 1.1		
				J.	1847	6	11.9	— 1.5		
				Ja.	1850	4	10.6	— 0.2		
				Ad.			54 50 10.4			
3075	3.4	8 53 59	+ 4.1	M.		156	47 42 37.2		— 13.80	— 0.10
				J. 2	1856	6	37.6	— 0.2		
				Ou.	1849	(13)	39.2	+ 0.0		
				Ad.			47 42 37.3			
3097	5	8 57 33	+ 3.9	Gr.		10	39 0 47.1	+ 0.3	— 14.03	— 0.06
				T.		10	46.2	+ 0.7		
				Ai.	1840	4	47.5	+ 0.5		
				J.	1845	4	47.9	— 1.5		
				Ad.			39 0 47.4			
3100	7	8 57 49	+ 3.8	Gr.		2	38 50 25.3	+ 0.2	— 14.05	
				J.	1846	3	24.5	— 1.4		
				Ja.	1850	4	22.6	— 0.2		
				Ad.			38 50 22.1			
3106	5	8 58 54	+ 4.3	M.		36	52 10 13.6		— 14.11	— 0.05
				J. 2	1854	3	14.1	— 0.2		
				Ad.			52 10 13.6			
3109	6	8 59 32	+ 3.6	M.		20	30 13 5.8		— 14.15	0.00
3140	5	9 6 1	+ 4.4	M.		123	54 36 2.1		— 14.55	+ 0.08
				J. 2	1856	7	2.1	— 0.1		
				Ad.			54 36 2.1			
3150	6	9 8 2	+ 4.1	Gr.		6	47 24 7.0	+ 0.0	— 14.67	+ 0.03
				T.		4	5.7	+ 0.1		
				J.	1846	7	7.6	— 1.6		
				Ad.			47 24 5.4			
3162	4	9 10 4	+ 3.8	M.		71	37 23 48.0		— 14.79	— 0.09
3172	6	9 11 21	+ 4.5	Gr.		6	57 17 36.8		— 14.87	
				J.	1847	6	37.4	— 1.3		
				Ja.	1850	5	36.4	— 0.2		
				Ad.			57 17 35.9			
3178	3.4	9 12 28	+ 3.7	M.		105	34 59 9.8		— 14.93	0.00

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		h m s	s				° ′ ″	″		
3178	3.4	9 12 28	+3.7	J. 2	1855	6	34 59 11.6	—0.2		
				Ad.			34 59 10.0			
3218	6	9 19 25	+4.0	M.		52	46 12 58.9		—15.33	—0.16
				J. 2	1855	3	59.4	—0.2		
				Ad.			46 12 58.9			
3256	5	9 25 9	+4.2	M.		34	52 40 32.8		—15.65	—0.04
3261	5	9 25 35	+3.7	M.		46	37 1 15.9		—15.67	—0.03
				Ai. 2	1857	3	15.9	+0.5		
				Ad.			37 1 16.0			
3265	(6)	9 26 15	+3.8	Gr.		6	40 14 43.3	+0.3	—15.71	—0.05
				T.		4	40.5	+0.6		
				J.	1847	6	43.2	—1.5		
				Ad.			40 14 40.6			
3281	6	9 29 33	+3.8	M.		28	40 52 13.7		—15.89	—0.01
				Ai. 2	1856	1	15.0	+0.4		
				Ad.			40 52 13.8			
3307	6	9 33 15	+3.7	M.		24	40 23 53.3		—16.09	—0.05
3317	5	9 35 17	+3.5	M.		22	30 37 14.3		—16.19	—0.10
				J. 2	1855	5	14.1	—0.2		
				Ad.			30 37 14.2			
3324	6	9 36 30	+4.3	M.		35	57 46 20.9		—16.25	—0.01
3341	6	9 39 29	+3.9	M.		54	46 40 31.0		—16.40	—0.11
				J. 2	1854	2	31.9	—0.2		
				Ad.			46 40 31.0			
3346	4.3	9 40 56	+4.3	M.		273	59 41 55.7		—16.48	—0.20
				Ai. 2	1857	2	57.0	—0.3		
				Ad.			59 41 55.7			
3352	6.7	9 41 33	+3.7	M.		30	40 17 10.0		—16.51	+0.01
3358	5.4	9 42 29	+4.1	M.		70	54 43 13.3		—16.55	—0.02
3381	5	9 46 29	+4.0	M.		33	50 28 59.2		—16.75	0.00
				Ou.	1849	(3)	59.0	+0.0		
				Ad.			50 28 59.2			
3399	5	9 49 2	+3.7	M.		35	41 43 30.1		—16.87	—0.03
				Ai. 2	1856	5	29.4	+0.3		
				Ad.			41 43 30.0			
3402	6	9 50 8	+4.2	Gr.		6	57 29 4.4	+0.1	—16.92	
				J.	1845	5	5.3	—1.3		
				Ja.	1850	4	3.6	—0.2		
				Ad.			57 29 3.5			
3446	4.5	9 59 6	+3.6	M.		48	35 55 48.4		—17.33	0.00
				J. 2	1856	5	47.5	—0.3		
				Ad.			35 55 48.2			
3505	3.4	10 8 34	+3.7	M.		334	43 37 0.2		—17.73	—0.09
3533	3	10 13 55	+3.6	M.		197	42 12 24.8		—17.94	0.00
				Ai. 2	1857	5	25.2	+0.3		
				J. 2	1857	3	26.3	—0.2		
				Ad.			42 12 24.9			
3565	6	10 19 6	+3.6	Gr.		6	42 19 17.6	+0.3	—18.14	+0.06
				T.		4	14.4	+0.5		
				J.	1847	4	15.3	—1.5		
				Ad.			42 19 12.5			
3567	6	10 19 24	+3.7	Fed.	1790	1	49 33 13.5	—0.4	—18.15	
				Gr.		6	49 32 52.7	—0.1		
				J.	1846	6	23.8	—1.6		
				Ja.	1850	4	17.0	—0.2		
				Ou.	1850	(8)	19.1	+0.0		
				Ad.			49 32 9.8			
3572	4.5	10 19 43	+3.5	M.		79	37 25 41.5		—18.17	—0.11

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3572	4.5	10 19 43	+ 3.5	J. 2	1854	1	37 25 42.5	— 0.2		
				Ad.			37 25 41.5			
3580	5	10 21 35	+ 3.9	M.		73	56 42 7.5		—18.23	— 0.01
				J. 2	1857	7	7.2	— 0.1		
				Ad.			56 42 7.4			
3607	5	10 25 0	+ 3.5	Gr.		6	41 8 59.6	+ 0.3	—18.36	
				J.	1846	6	9 1.1	— 1.5		
				Ja.	1850	4	9 0.0	— 0.2		
				Ad.			41 8 59.6			
3612	5	10 26 3	+ 3.9	M.		115	57 48 24.8		—18.39	— 0.01
				J. 2	1855	4	26.2	+ 0.0		
				Ad.			57 48 24.9			
3639	6	10 30 20	+ 3.8	Gr.		6	54 24 15.1	— 0.1	—18.54	
				J.	1843	4	11.8	— 1.5		
				Ja.	1850	4	11.4	— 0.2		
				Ad.			54 24 8.8			
3640	5.4	10 30 47	+ 3.4	M.		67	32 42 26.7		—18.55	0.00
3665	5	10 35 15	+ 3.6	Gr.		7	46 56 41.9	+ 0.0	—18.70	+ 0.03
				T.		4	39.1	+ 0.1		
				J.	1843	5	38.9	— 1.6		
				Ad.			46 56 35.5			
3685	5	10 38 1	+ 3.3	M.		75	31 25 25.2		—18.79	— 0.05
				Ai. 2	1857	4	25.1	+ 0.6		
				Ad.			31 25 25.3			
3713	6	10 42 28	+ 3.8	M.		29	57 19 38.1		—18.92	— 0.04
3725	5	10 45 1	+ 3.7	M.		43	55 19 59.8		—18.99	— 0.04
3728	4	10 45 25	+ 3.4	M.		59	34 58 27.3		—19.00	— 0.25
				J. 2	1855	5	27.2	— 0.2		
				Ad.			34 58 27.3			
3729	5	10 45 51	+ 3.5	M.		119	43 56 22.5		—19.01	— 0.04
				Ai. 2	1857	4	22.7	+ 0.0		
				Ad.			43 56 22.5			
3757	5	10 51 33	+ 3.4	M.		38	41 10 55.6		—19.17	+ 0.04
				J. 2	1857	4	57.2	— 0.2		
				Ad.			41 10 55.8			
3758	6	10 52 8	+ 3.5	Gr.		6	46 16 52.1	+ 0.1	—19.18	
				J.	1847	4	53.6	— 1.6		
				Ja.	1850	4	51.1	— 0.2		
				Ad.			46 16 51.5			
3765	5	10 52 56	+ 3.4	M.		29	39 58 7.9		—19.20	0.00
3767	2.3	10 53 19	+ 3.7	M.		262	57 8 13.1		—19.21	0.00
				J. 2	1854	2	14.4	+ 0.0		
				Ad.			57 8 13.1			
3811	6	11 1 33	+ 3.3	Lal.	1794	1	37 4 25.3	— 1.6	—19.41	— 0.02
				T.		4	24.4	+ 0.7		
				Ad.			37 4 25.1			
3812	3	11 1 43	+ 3.4	M.		297	45 15 44.6		—19.41	— 0.08
3846	6	11 8 44	+ 3.4	Gr.		6	50 14 44.9	— 0.1	—19.56	— 0.01
				T.		4	40.8	+ 0.1		
				J.	1845	3	43.4	— 1.6		
				Ad.			50 14 39.4			
3852	3.4	11 10 51	+ 3.3	M.		91	33 51 46.6		—19.59	— 0.02
3856	5	11 11 26	+ 3.3	M.		47	38 57 30.5		—19.61	+ 0.09
3864	6	11 14 27	+ 3.6	Gr.		6	65 6 3.6	+ 0.6	—19.66	— 0.06
				T.		4	2.2	+ 0.3		
				J.	1847	5	5.8	— 0.8		
				Ad.			65 6 4.2			
3905	5	11 21 28	+ 3.3	M.		36	40 6 45.4		—19.77	+ 0.01

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3931	6	11 27 17	+3.3	Gr.		6	55 33 51.2	+0.0	−19.85	
				J.	1843	4	51.8	−1.4		
				Ja.	1850	4	50.5	−0.2		
				Ad.			55 33 50.0			
3933	6	11 27 44	+3.6	M.		34	70 6 24.2		−19.86	−0.14
				J. 2	1857	6	24.7	+0.5		
				Ad.			70 6 24.5			
3965	5	11 33 37	+3.2	M.		28	34 59 51.6		−19.92	−0.40
				J. 2	1855	4	53.7	−0.2		
				Ad.			34 59 52.0			
3981	4	11 38 36	+3.2	M.		211	48 33 38.9		−19.96	−0.01
3985	6	11 39 21	+3.3	Gr.		6	56 24 46.1	+0.0	−19.97	
				J.	1843	4	47.4	−1.4		
				Ja.	1850	4	45.0	−0.2		
				Ad.			56 24 45.4			
4057	5	11 54 57	+3.1	M.		71	43 49 39.9		−20.05	+0.04
				J. 2	1857	4	40.5	−0.2		
				Ad.			43 49 39.9			
4108	7	12 4 42	+3.0	M.		30	57 50 21.0		−20.05	−0.04
4123	3.4	12 8 26	+3.0	M.		Omitted.	57 48 58.0		−20.04	−0.03
4152	(6.7)	12 13 13	+3.0	T.		2	26 47 2.5	+0.4	−20.02	+0.09
				Ad.			26 47 5.1			
4169	5	12 15 25	+3.0	M.		47	26 37 44.7		−20.01	+0.01
4181	5	12 17 14	+3.0	M.		50	26 52 51.5		−20.00	−0.03
				Ai. 2	1854	6	51.1	+0.3		
				Ad.			26 52 51.5			
4199	7	12 20 35	+3.0	Lal.	1794	1	26 41 41.8	−0.6	−19.97	
				R.		1	35.2	+0.6		
				Ja.	1850	4	35.0	−0.2		
				J. 2.	1857	3	36.3	−0.2		
				Ad.			26 41 35.5			
4206	(7)	12 21 42	+3.0	M.		9	26 40 51.8		−19.97	+0.03
4207	5	12 21 52	+3.0	M.		24	26 41 37.3		−19.97	−0.02
4240	5	12 27 50	+3.0	Pi.			23 24 23.0	−1.4	−19.90	0.00
				T.		5	22.1	+0.4		
				R.		2	22.6	+0.5 ?		
				J. 2	1857	1	22.0	−0.2		
				Ad.			23 24 22.9			
4305	6	12 42 30	+2.6	Gr.		6	61 5 22.1	+0.3	−19.71	
				R.		4	23.7	−1.5		
				J.	1846	6	23.8	−1.1		
				Ja.	1850	4	21.5	−0.2		
				Ad.			61 5 22.3			
4341	6	12 48 30	+2.8	Gr.		6	47 57 43.8	+0.0	−19.61	
				J.	1846	4	45.2	−1.6		
				Ja.	1850	4	42.1	−0.2		
				Ad.			47 57 42.8			
4384	5	12 59 9	+2.8	M.		65	36 33 15.9		−19.39	+0.01
4421	4	13 5 18	+2.8	M.		48	28 35 38.8		−19.25	+0.89
				J. 2	1854	3	38.6	−0.2		
				Ai. 2	1853	5	38.5	+0.4		
				Ad.			28 35 38.8			
4484	2	13 18 14	+2.4	M.		563	55 39 45.0		−18.90	−0.06
				J. 2	1855	3	43.8	−0.1		
				Ad.			45.0			
4486	4.5	13 18 16	+2.4	Br.	1755	3	55 39 38.1		−18.90	−0.06
				Gr.		5	35.3	+0.0		
				T.		7	55 39 34.3	+0.1		

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4486	4.5	13 18 16	+ 2.4	Ai.	1838	72	55 39 33.8	— 0.5		
				J.	1847	8	34.6	— 1.4		
				J. 2	1857	1	36.4	— 0.1		
				Ad.			55 39 32.1			
4493	5	13 19 34	+ 2.4	M.		62	55 43 24.0		— 18.86	— 0.05
				J. 2	1856	1	24.5	+ 0.0		
				Ad.			55 43 24.0			
4519	6	13 25 9	+ 2.6	Lal.	1793	1	42 49 58.6	— 0.8	— 18.69	
				R.	1842	3	58.0	— 0.4		
				Ai.	1843	17	57.6	+ 0.3		
				J.	1845	3	60.5	— 1.5		
				Ja.	1850	4	57.1	— 0.2		
				Ad.			42 49 58.0			
4596	6.5	13 40 14	+ 2.6	Gr.		6	41 47 52.5	+ 0.3	— 18.17	
				R.	1841	1	47.0	— 0.4		
				Ai.	1844	16	50.9	+ 0.3		
				J.	1844	4	52.0	— 1.5		
				Ja.	1857	2	50.7	— 0.2		
				Ad.			41 47 50.1			
4609	6	13 42 8	+ 2.5	Gr.		5	42 45 14.4	+ 0.3	— 18.10	
				J.	1843	5	15.8	— 1.5		
				Ja.	1851	4	12.9	— 0.2		
				Ad.			42 45 13.4			
4676	(7)	13 55 7	+ 2.7	Ja.	1850	4	32 14 52.4	— 0.2	— 17.57	
				Ad.			32 14 52.2			
4678	(7)	13 56 19	+ 2.7	Ja.	1850	4	32 20 27.9	— 0.2	— 17.52	
				Ad.			32 20 27.7			
4726	4.5	14 8 26	+ 2.2	M.		59	52 27 1.3		— 16.99	— 0.04
4728	6	14 8 42	+ 2.4	Gr.		6	42 10 61.7	+ 0.3	— 16.97	
				J.	1844	3	59.9	— 1.5		
				Ja.	1850	4	57.3	— 0.2		
				Ad.			42 10 56.6			
4789	4.3	14 20 24	+ 2.0	M.		238	52 30 17.4		— 16.41	— 0.43
				J. 2	1857	6	14.9	— 0.2		
				Ad.			52 30 17.3			
4805	6.7	14 24 3	+ 2.4	Gr.		6	42 26 11.5	+ 0.3	— 16.22	
				J.	1844	5	7.5	— 1.5		
				Ja.	1850	4	3.1	— 0.2		
				Ai. 2	1856	2	3.0	+ 0.2		
				Ad.			42 26 2.6			
4843	6	14 33 35	+ 2.2	M.		37	45 0 53.3		— 15.72	— 0.02
4918	6	14 47 51	+ 1.5	Gr.		6	59 51 58.2	+ 0.2	— 14.91	+ 0.07
				T.		8	62.3	+ 0.2		
				Ai.	1843	15	63.3	— 0.3		
				J.	1848	4	64.9	— 1.2		
				J. 2	1859	4	66.0	+ 0.1		
				Ad.			59 52 5.3			
4943	5	14 54 12	+ 2.3	M.		26	39 49 35.7		— 14.53	+ 0.05
				Ai. 2	1855	4	34.8	+ 0.4		
				Ad.			39 49 35.6			
4961	6	14 57 29	+ 2.4	Pi.			35 45 37.1	— 0.6	— 14.34	+ 0.00
				T.		3	36.1	+ 0.7		
				R.	1844	7	35.0	+ 0.0		
				Ad.			35 45 35.8			
4980	5	15 0 45	+ 2.0	Gr.		6	48 41 49.5	— 0.1	— 14.13	
				Ai.	1846	1	50.9	— 0.6		
				J.	1843	3	51.9	— 1.6		
				Ja.	1850	4	48 41 49.6	— 0.2		

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		h m s	s				° ′ ″	″	″	″
4980	5	15 0 45	+2.0	J. 2	1857	1	48 41 50.0	−0.2		
				Ad.			48 41 50.1			
5157	6.7	15 30 20	+2.1	Gr.		6	43 38 8.1	+0.2	−12.19	
				J.	1844	5	11.9	−1.5		
				Ja.	1851	5	8.6	−0.2		
				Ad.			43 38 10.2			
5287	6	15 49 56	+2.0	M.		34	43 33 4.8		−10.78	+0.07
5310	6	15 53 45	+2.2	T.		4	37 2 43.6	+0.7	−10.50	+0.02
				Ad.			37 2 44.3			
5316	6	15 55 4	+1.7	Gr.		6	50 17 5.4	−0.1	−10.40	
				J.	1846	5	5.7	−1.6		
				Ou.	1849	(25)	4.9	+0.0		
				Ja.	1851	4	1.9	−0.2		
				Ad.			50 17 3.8			
5336	6	15 58 9	+2.2	Lal.	1794	1	37 1 26.5	−1.0	−10.17	−0.03
				T.		3	20.7	+0.7		
				Ad.			37 1 21.4			
5385	5.4	16 3 49	+2.2	M.		32	36 51 6.0		−9.74	+0.36
				J. 2	1857	5	5.2	−0.2		
				Ad.			36 51 5.8			
5479	(5)	16 17 3	+2.3	Pi.			34 8 3.4	−0.8	−8.71	−0.08
				T.		5	7 59.6	+0.7		
				Ad.			34 7 58.7			
5480	(5)	16 17 10	+2.3	T.		5	34 2 1.4	+0.7	−8.70	−0.02
				Ad.			34 2 2.1			
5574	6	16 32 52	+1.4	M.		85	53 11 4.4		−7.45	0.00
5575	6.5	16 32 54	+1.4	M.		91	53 12 31.7		−7.44	−0.02
5652	(6.7)	16 43 46	+2.3	M.		12	30 12 35.0		−6.55	+0.12
5752	6	16 56 46	+1.1	Gr.		6	56 53 46.5	+0.0	−5.47	
				Arg.	1830	8	47.9	−0.4		
				T.		4	48.8	+0.1		
				Ai.	1843	4	48.0	−0.5		
				J.	1846	5	49.2	−1.4		
				J. 2	1859	4	48.9	+0.0		
				Ad.			56 53 48.4			
5997	6.7	17 36 21	+1.8	Gr.		6	43 32 27.6	+0.2	−2.07	
				R.	1847	1	35.3	−0.5		
				J.	1847	6	32.7	−1.5		
				Ja.	1850	4	28.1	−0.2		
				Ad.			43 32 31.5			
6013	6	17 38 55	+1.8	Gr.		6	44 8 50.1	+0.2	−1.84	
				R.	1847	2	52.9	−0.5		
				J.	1846	5	53.8	−1.5		
				Ja.	1850	4	52.8	−0.2		
				Ad.			44 8 53.0			
6151	6	18 2 8	+2.4	M.		28	26 4 44.7		+0.19	+0.03
				J. 2	1856	4	44.6	−0.2		
				Ad.			26 4 44.6			
6193	6.7	18 8 23	+2.0	Gr.		6	38 44 9.7	+0.2	+0.74	
				R.	1847	1	9.6	−0.1		
				J.	1845	4	12.5	−1.4		
				Ja.	1851	4	10.7	−0.2		
				Ad.			38 44 11.1			
6224	5	18 13 5	+0.3	M.		171	64 20 58.7		+1.14	0.00
				J. 2	1856	5	59.2	+0.3		
				Ai. 2	1857	12	59.9	−0.2		
				Ad.			64 20 58.8			
6235	5.4	18 14 55	+2.1	M.		54	36 0 12.1		+1.25	+0.04

B. A. C.	Mag.	α 1859.0.	Annual Variation.	Authority.	Mean Year.	No. Obs.	δ 1859.0.	Systematic Correction.	Precession.	Proper Motion.
		h m s	s				° ′ ″	″	″	
6246	6	18 16 38	+1.4	Gr.		6	51 17 14.3	−0.2	+1.46	
				Ai.	1840	12	14.8	−0.6		
				J.	1844	4	16.5	−1.5		
				Ja.	1851	4	14.3	−0.2		
				Ou.	1849	(39)	14.7	+0.0		
				Ad.			51 17 14.6			
6255	5	18 17 56	+1.5	Gr.		6	49 3 2.9	−0.1	+1.57	
				R.	1843	3	5.0	−0.9		
				Ai.	1842	12	6.4	−0.6		
				J.	1848	4	7.9	−1.6		
				Ja.	1850	4	6.2	−0.2		
				Ou.	1849	(38)	7.6	+0.0		
				Ad.			49 3 7.5			
6258	6.7	18 18 10	+1.4	Gr.		5	51 14 2.9	−0.2	+1.59	
				R.	1847	1	2.7	−1.0		
				Ai.	1845	6	2.3	−0.6		
				J.	1846	5	5.3	−1.5		
				Ja.	1851	4	4.4	−0.2		
				Ou.	1849	(41)	3.2	+0.0		
				Ad.			51 14 3.0			
6349	7	18 30 38	+2.0	M.		33	38 46 55.4		+2.67	−0.″04
				J. 2	1855	4	55.3	−0.2		
				Ad.			38 46 55.4			
6392	5.4	18 39 55	+2.1	Br.	1755	2	37 27 32.5		+3.48	+0.02
				Str.	1830	6	34.6	+0.5		
				R.	1843	6	34.6	−0.1		
				Ad.			37 27 35.7			
6394	6	18 39 57	+2.1	M.		24	37 26 57.2		+3.48	0.00
6419	6.7	18 43 34	+1.3	Gr.		6	52 50 4.2	−0.2	+3.79	
				R.	1843	6	4.7	−1.0		
				J.	1846	6	5.1	−1.5		
				Ja.	1851	4	4.1	−0.2		
				Ad.			52 50 3.6			
6421	7.8	18 43 51	+1.5	Gr.		6	49 16 36.1	−0.1	+3.82	
				J.	1846	5	39.2	−1.6		
				Ja.	1851	4	35.9	−1.2		
				Ad.			49 16 37.3			
6428	6	18 44 33	+1.6	Gr.		6	48 36 23.8	+0.0	+3.87	
				R.	1847	1	27.0	−0.8		
				Ai.	1840	11	26.6	−0.5		
				J.	1844	3	28.7	−1.6		
				Ja.	1851	4	28.5	−0.2		
				Ou.	1849	(27)	28.1	+0.0		
				Ad.			48 36 28.2			
6452	6	18 48 25	+1.3	Gr.		6	52 47 26.7	−0.2	+4.21	
				J.	1844	4	36.1	−1.5		
				Ja.	1851	4	35.8	−0.2		
				Ad.			52 47 37.9			
6456	(6)	18 48 48	+2.1	M.		40	36 47 50.1		+4.24	−0.02
6466	(4.5)	18 49 34	+2.1	M.		55	36 43 18.1		+4.30	0.00
6468	(6.7)	18 49 43	+2.2	M.		7	33 47 27.6		+4.32	−0.03
				Ja.	1850	4	26.8	−0.2		
				Ad.			33 47 27.1			
6470	5	18 49 44	+1.5	Gr.		6	50 32 3.5	−0.1	+4.32	
				R.	1841	3	4.2	−0.9		
				J.	1845	5	5.6	−1.6		
				Ja.	1851	4	3.0	−0.2		
				Ou.	1849	(50)	50 32 3.9	+0.0		

B. A. C.	Mag.	α 1859.0.	Annual Variation.	Authority.	Mean Year.	No. Obs.	δ 1859.0.	Systematic Correction.	Precession.	Proper Motion.
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6470	5	18 49 44	+1.5	Ad.			50 32 3.8			
6476	6	18 51 4	+1.6	Gr.		6	48 41 9.5	+0.0	+4.43	—0.12
				T.		4	7.1	+0.1		
				R.	1844	2	7.4	—0.8		
				J.	1843	3	8.2	—1.6		
				Ad.			48 41 5.4			
6480	6	18 51 43	+2.2	M.		20	32 43 21.5		+4.49	—0.18
				Ja.	1850	4	21.8	—0.2		
				J. 2	1856	4	22.8	—0.2		
				Ad.			32 43 21.8			
6491	3.4	18 53 40	+2.2	M.		153	32 29 56.0		+4.65	0.00
				J. 2	1858	2	55.3	—0.2		
				Ad.			32 29 56.0			
6493	6	18 54 10	+2.0	Gr.		6	40 29 14.6	+0.3	+4.69	
				Str.	1834	3	16.8	+0.5		
				J.	1844	4	16.4	—1.5		
				Ja.	1850	4	16.3	—0.2		
				Ad.			40 29 16.4			
6495	6	18 54 27	+2.0	Gr.		6	39 1 27.3	+0.3	+4.73	
				R.	1842	1	28.5	—0.2		
				J.	1847	4	29.5	—1.5		
				Ja.	1850	5	27.5	—0.2		
				Ad.			39 1 27.8			
6496	6	18 54 22	+1.0	M.		113	57 37 43.4		+4.71	—0.07
6500	7	18 55 9	+1.0	Gr.		6	58 1 54.6	+0.1	+4.78	—0.06
				Str.	1830	5	55.2	—0.3		
				T.		3	53.2	+0.1		
				R.	1843	3	56.1	—1.3		
				J.	1847	4	57.1	—1.3		
				Ad.			58 1 55.6			
6516	6	18 57 15	+1.6	Gr.		6	47 50 6.2	+0.0	+4.96	
				J.	1846	3	11.3	—1.6		
				Ja.	1850	4	9.4	—0.2		
				Ad.			47 50 10.6			
6520	5	18 57 27	+1.7	Gr.		12	46 44 15.8	+0.1	+4.97	—0.06
				T.		3	12.7	+0.2		
				R.	1842	1	9.8	—0.7		
				J.	1846	6	14.3	—1.6		
				J. 2	1858	2	10.8	—0.2		
				Ad.			46 44 11.0			
6530	6.7	18 58 48	+1.4	Gr.		6	52 3 28.0	—0.2	+5.09	
				Str.	1828	4	27.2	—0.4		
				Ai.	1841	13	27.9	—0.6		
				J.	1845	3	30.0	—1.5		
				Ja.	1851	4	26.7	—0.2		
				Ad.			52 3 27.4			
6534	(6)	18 59 35	+2.3	Lal.	1794	1	31 32 21.0	—1.4	+5.16	
				Ja.	1851	4	9.9	—0.2		
				Ad.			31 32 8.3			
6556	5	19 2 16	+2.1	M.		38	35 52 51.8		+5.38	—0.02
6593	6.7	19 11 3	+2.0	Gr.		11	40 6 54.3	+0.3	+6.12	
				R.	1846	1	50.6	—0.2		
				J.	1842	4	55.9	—1.5		
				Ja.	1850	4	52.3	—0.2		
				Ad.			40 6 52.9			
6599	4.5	19 11 28	+2.1	M.		50	37 53 4.9		+6.15	—0.02
6601	5.6	19 11 24	+1.1	M.		65	57 27 44.7		+6.15	—0.11
6623	4	19 13 50	+1.4	M.		261	53 6 34.2		+6.35	+0.10

B. A. C.	Mag.	α 1859.0.	Annual Variation.	Authority.	Mean Year.	No. Obs.	δ 1859.0.	Systematic Correction.	Precession.	Proper Motion.
		h m s	s				° ′ ″	″	″	″
6623	4	19 13 50	+1.4	Ai. 2	1856	14	53 6 34.5	−0.6		
				Ad.			53 6 34.2			
6624	6.7	19 14 15	+2.0	Gr.		6	40 6 7.8	+0.3	+6.38	
				J.	1842	3	9.9	−1.5		
				Ja.	1851	4	9.6	−0.2		
				Ad.			40 6 9.1			
6626	7	19 14 52	+1.6	Gr.		6	49 18 31.9	−0.1	+6.44	
				R.	1843	1	33.5	−0.9		
				J.	1846	5	36.2	−1.6		
				Ja.	1850	5	32.8	−0.2		
				Ad.			49 18 34.4			
6640	6	19 17 41	+1.1	Gr.		6	57 22 44.3	+0.1	+6.66	
				R.	1840	2	47.4	−1.3		
				J.	1845	12	45.3	−1.3		
				Ja.	1851	4	47.1	−0.2		
				Ad.			57 22 44.6			
6648	5	19 18 34	+2.4	M.		39	29 20 53.9		+6.74	+0.04
6659	7.8	19 19 42	+1.6	Gr.		7	49 59 47.6	−0.1	+6.84	−0.10
				T.		6	49.2	+0.1		
				Ai.	1843	4	50.2	−0.6		
				J.	1847	4	51.2	−1.6		
				Ou.	1849	(43)	49.1	+0.0		
				Ad.			49 59 50.0			
6673	(7)	19 22 39	+2.4	Lal.	1794	1	29 9 57.6	−1.5	+7.07	
				T.		3	55.6	+0.5		
				Ad.			29 9 56.1			
6681	8	19 23 14	+1.1	Gr.		6	57 44 36.3	+0.1	+7.12	−0.08
				T.		4	39.2	+0.1		
				R.	1844	2	40.4	−1.3		
				J.	1847	6	40.7	−1.3		
				Ad.			57 44 40.4			
6697	4	19 26 9	+1.5	Br.	1755	34	51 25 37.8		+7.36	+0.10
				Gr.		107	44.0	−0.2		
				T.		5	46.1	+0.0		
				Ai.	1839	44	49.0	−0.6		
				J.*	1844	6	50.0	−1.5		
				Ai. 2	1856	8	50.2	−0.6		
				J. 2	1858	5	50.5	−0.2		
				Ad.			51 25 50.7			
6711	6.7	19 28 41	+2.1	Gr.		6	38 27 22.8	+0.2	+7.57	
				R.	1845	6	24.5	−0.1		
				J.	1848	3	26.4	−1.4		
				Ja.	1850	4	24.1	−0.2		
				Ad.			38 27 24.9			
6717	7	19 29 49	+1.7	Gr.		11	48 57 22.9	+0.0	+7.66	
				R.	1847	1	25.5	−0.8		
				J.	1844	3	25.7	−1.6		
				Ja.	1850	4	24.6	−0.2		
				Ad.			48 57 24.8			
6718	6	19 30 5	+2.0	Gr.		6	42 6 18.8	+0.3	+7.68	
				R.	1844	2	20.4	−0.4		
				J.	1846	4	22.5	−1.5		
				Ja.	1850	4	20.4	−0.2		
				Ad.			42 6 21.1			
6722	6	19 30 44	+2.2	M.		22	36 38 1.3		+7.74	+0.01
6723	6	19 30 41	+1.6	Gr.		6	50 56 17.1	−0.1	+7.73	−0.10
				T.		2	12.4	+0.1		
				Ou.	1849	(22)	50 56 10.9	+0.0		

* Omitting S. P. Observations

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		h m s	s				° ′ ″	″	″	″
6723	6	19 30 41	+1.6	J.	1842	4	50 56 13.7	−1.6		
				Gr.	1859	3	7.9	−0.2		
				Ad.			50 56 8.5			
6730	8	19 32 9	+1.6	M.		22	49 55 25.8		+7.85	+0.05
				Ai. 2	1855	2	26.9	−0.6		
				Ad.			49 55 25.9			
6734	5.4	19 32 40	+1.6	M.		274	49 53 46.0		+7.89	+0.25
				J. 2	1856	3	46.1	+0.2		
				Ai. 2	1855	3	45.9	−0.6		
				Ad.			49 53 46.0			
6741	7	19 34 2	+1.7	Gr.		5	48 57 25.6	+0.0	+8.00	
				T.		3	22.7	+0.1		
				R.	1842	2	30.1	−0.8		
				J.	1844	5	32.7	−1.6		
				J. 2	1859	6	32.8	−0.2		
				Ad.			48 57 33.0			
6745	6.5	19 34 51	+2.0	M.		28	42 29 40.0		+8.07	+0.04
				Ai. 2	1856	11	38.9	+0.3		
				Ad.			42 29 39.7			
6754	6.5	19 36 29	+1.8	Gr.		6	45 11 28.5	+0.1	+8.19	
				J.	1844	4	33.2	−1.6		
				Ja.	1850	3	31.9	−0.2		
				Ad.			45 11 32.7			
6763	6	19 38 4	+1.6	M.		82	50 11 58.0		+8.32	−0.15
				Ai. 2	1856	17	58.0	−0.6		
				J. 2	1857	3	57.4	−0.2		
				Ad.			50 11 57.8			
6764	6.7	19 38 7	+1.6	M.		55	50 11 31.0		+8.33	−0.15
				Ai. 2	1856	16	31.1	−0.6		
				J. 2	1858	1	31.0	−0.2		
				Ad.			50 11 30.8			
6765	6.5	19 38 13	+2.1	Gr.		6	38 20 14.6	+0.2	+8.34	
				R.	1846	1	12.2	−0.1		
				J.	1844	3	18.4	−1.4		
				Ja.	1850	4	15.2	−0.2		
				Ad.			38 20 16.1			
6769	6	19 39 3	+2.0	Gr.		6	41 26 10.2	+0.3	+8.40	
				J.	1846	3	13.3	−1.5		
				Ja.	1850	4	11.6	−0.2		
				Ad.			41 26 12.0			
6777	6	19 40 36	+2.2	Str.	1824	6	34 40 16.8	+0.5	+8.53	
				T.		3	16.2	+0.7		
				Ad.			34 40 17.2			
6780	6	19 40 28	+1.2	Gr.		6	57 40 54.4	+0.1	+8.51	
				R.	1847	1	54.5	−1.3		
				J.	1846	7	55.3	−1.3		
				Ja.	1851	4	53.0	−0.2		
				Ad.			57 40 53.3			
6784	5.6	19 41 5	+2.3	M.		44	33 24 7.2		+8.56	−0.43
				J. 2	1856	2	7.0	−0.2		
				Ad.			33 24 7.2			
6799	6	19 43 20	+1.8	Gr.		4	47 33 37.6	+0.0	+8.74	
				J.	1847	8	38.9	−1.6		
				Ja.	1851	4	38.0	−0.2		
				Ad.			47 33 37.5			
6800	7	19 43 28	+2.3	Lal.	1798	1	33 5 17.8	−1.4	+8.75	−0.06
				T.		3	11.5	+0.7		
				J. 2	1856	5	12.3	+0.1		

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		h m s	s				° ′ ″	″	″	″
6800	7	19 43 28	+2.3	Ad.			33 5 12.3			
6806	6	19 44 28	+2.1	Gr.		6	38 21 25.7	+0.2	+ 8.83	−0.05
				T.		3	24.9	+0.7		
				J.	1847	4	28.1	−1.4		
				J. 2	1857	3	26.0	−0.2		
				Ad.			38 21 26.5			
6813	6	19 45 34	+2.1	Gr.		5	38 21 35.6	+0.2	+ 8.91	+0.13
				J.	1845	3	42.7	−1.4		
				Ja.	1851	5	40.4	−0.2		
				J. 2	1857	1	42.0	−0.2		
				Ad.			38 21 42.0			
6817	6	19 45 47	+2.1	Gr.		6	40 14 35.0	+0.3	+ 8.93	
				Ai.	1842	6	35.4	+0.4		
				J.	1843	5	36.0	−1.5		
				Ja.	1850	4	34.0	−0.2		
				Ad.			40 14 34.9			
6824	5.6	19 47 5	+1.5	M.		80	52 37 52.8		+ 9.03	−0.08
				Ai. 2	1856	4	53.4	−0.6		
				Ad.			52 37 52.8			
6830	6	19 47 58	+1.8	Gr.		6	47 34 8.6	+0.0	+ 9.10	
				J.	1842	3	10.4	−1.6		
				Ja.	1850	4	10.5	−0.2		
				Ad.			47 34 9.7			
6849	5.6	19 50 49	+2.1	M.		35	38 6 50.7		+ 9.32	−0.01
6856	5	19 51 59	+1.6	M.		33	52 3 57.8		+ 9.41	−0.01
6857	6.5	19 52 20	+2.1	Gr.		6	39 59 26.5	+0.3	+ 9.44	
				J.	1846	3	28.8	−1.5		
				Ja.	1850	6	25.8	−0.2		
				Ad.			39 59 26.6			
6860	7	19 52 26	+2.1	Pi.			38 4 51.5	−0.5	+ 9.44	−0.05
				T.		4	49.2	+0.7		
				Ad.			38 4 49.2			
6862	7	19 52 28	+1.0	Gr.		6	60 14 28.5	+0.2	+ 9.45	
				J.	1848	4	30.0	−1.2		
				Ja.	1851	4	27.4	−0.2		
				Ad.			60 14 27.8			
6865	6	19 52 54	+1.6	Gr.		6	50 31 28.0	−0.1	+ 9.49	
				Ai.	1843	6	29.8	−0.6		
				J.	1844	4	31.8	−1.6		
				Ja.	1851	4	29.5	−0.2		
				Ou.	1849	(22)	30.2	+0.0		
				Ad.			50 31 30.3			
6875	6.5	19 54 41	+2.2	M.		19	36 39 29.3		+ 9.62	+0.03
				J. 2	1855	3	31.5	−0.2		
				Ad.			36 39 29.8			
6895	6.5	19 57 22	+1.7	M.		41	49 42 48.6		+ 9.83	−0.01
				Ai. 2	1856	9	49.0	−0.6		
				Ad.			49 42 48.5			
6928	6.5	20 2 30	+1.6	Fed.	1790	1	52 44 46.0	−0.4	+10.22	
				Gr.		6	47.6	−0.2		
				J.	1843	4	57.8	−1.5		
				Ja.	1851	4	52 44 58.6	−0.2		
				Ad.			52 45 0.2			
6930	6	20 2 58	+0.8	Gr.		6	63 29 1.9	+0.5	+10.25	
				Str.	1829	5	4.4	+0.0		
				J.	1845	5	5.6	−0.9		
				Ja.	1851	4	6.6	−0.2		
				Ad.			63 29 5.9			

B. A. C.	Mag.	α 1859.0.	Annual Variation.	Authority.	Mean Year.	No. Obs.	δ 1859.0.	Systematic Correction.	Precession.	Proper Motion.
		h m s	s				° ′ ″	″	″	″
6937	5	20 4 12	+2.2	M.		43	36 25 36.6		+10.34	+0.05
6940	6	20 4 40	+2.5	M.		32	26 29 20.7		+10.39	+0.03
6943	6	20 5 54	+2.5	M.		45	26 23 26.5		+10.47	—0.03
6959	6	20 8 36	+1.7	Gr.		6	51 2 26.0	—0.2	+10.67	
				J.	1843	4	28.0	—1.5		
				Ja.	1851	4	26.8	—0.2		
				Ad.			51 2 26.8			
6962	4	20 8 52	+1.9	M.		30	46 23 25.7		+10.69	—0.02
6963	6	20 8 58	+2.0	Gr.		6	42 57 11.4	+0.3	+10.70	
				J.	1846	3	12.5	—1.5		
				Ja.	1849	5	10.7	—0.2		
				Ai. 2	1855	4	10.0	+0.2		
				Ad.			42 57 10.3			
6965	4	20 9 12	+1.9	M.		71	46 18 54.5		+10.71	0.00
				Ai. 2	1855	2	55.3	—0.3		
				Ad.			46 18 54.5			
6967	5	20 9 15	+2.2	M.		24	36 22 35.2		+10.72	+0.09
				J. 2	1855	4	35.3	—0.2		
				Ad.			36 22 35.2			
6969	(7.8)	20 9 23	+2.2	M.		8	36 19 29.0		+10.73	+0.05
6973	5	20 9 56	+2.5	M.		22	27 23 2.7		+10.77	+0.01
6978	(6)	20 10 36	+2.5	M.		14	27 20 39.2		+10.82	+0.01
6983	4.5	20 11 7	+1.9	M.		68	47 16 56.8		+10.86	—0.01
6985	6.7	20 11 37	+1.7	Gr.		6	49 47 58.6	—0.1	+10.90	
				J.	1847	3	60.5	—1.6		
				Ja.	1851	4	60.1	—0.2		
				Ad.			49 47 59.5			
6986	6	20 11 54	+2.1	M.		16	39 55 49.7		+10.92	—0.02
				Ja.	1851	4	49.5	—0.2		
				J. 2	1857	2	50.0	+0.0		
				Ad.			39 55 49.7			
6990	5	20 12 35	+2.2	M.		20	37 35 47.4		+10.97	—0.01
				J. 2	1855	2	46.0	+0.1		
				Ad.			37 35 47.2			
6996	6	20 13 7	+2.1	M.		20	40 17 39.8		+11.00	+0.01
6997	6	20 13 12	+2.2	M.		16	36 33 36.0		+11.01	0.00
7006	7	20 14 32	+2.2	Ja.	1851	5	36 41 25.4	—0.2	+11.11	+0.01
				J. 2	1855	4	26.2	+0.1		
				Ad.			36 41 26.1			
7008	6.7	20 15 8	+2.2	Gr.		6	38 57 37.0	+0.2	+11.15	
				Str.	1830	6	38.1	+0.5		
				J.	1850	4	37.9	—1.4		
				Ja.	1851	5	37.6	—0.2		
				Ad.			38 57 36.5			
7022	3.2	20 17 10	+2.2	M.		338	39 48 26.5		+11.30	+0.02
				J. 2	1857	9	26.8	+0.1		
				Ad.			39 48 26.5			
7024	6	20 17 15	+1.0	M.		53	61 48 36.3		+11.30	—0.01
7029	5	20 18 14	+2.4	M.		39	31 44 13.7		+11.37	+0.01
7035	6.7	20 19 22	+1.5	Gr.		6	54 13 9.5	—0.1	+11.46	
				J.	1849	5	11.1	—1.5		
				Ja.	1851	4	9.7	—0.2		
				Ad.			54 13 9.6			
7055	7	20 21 53	+1.6	Gr.		6	54 13 25.1	—0.1	+11.64	
				J.	1846	3	26.0	—1.5		
				Ja.	1851	3	(48.9)	—0.2		
				Ad.			54 13 24.3			
7062	6	20 22 44	+1.8	M.		116	48 55 0.7		+11.70	+0.03

B. A. C.	Mag.	α 1859.0.	Annual Variation.	Authority.	Mean Year.	No. Obs.	δ 1859.0.	Systematic Correction.	Precession.	Proper Motion.
		h m s	s				° ′ ″	″	″	″
7062	6	20 22 44	+1.8	Ai. 2	1856	8	48 55 1.7	−0.6		
				Ad.			48 55 0.8			
7073	6	20 23 58	+2.3	M.		22	35 59 9.9		+11.79	0.00
7076	7	20 24 10	+1.9	Lal.		1	48 27 4.0	−0.5	+11.80	
				T.		1	3.6	+0.1		
				J.	1847	3	7.3	−1.6		
				Ad.			48 27 5.7			
7083	6.7	20 25 19	+2.0	Gr.		6	45 26 54.5	+0.1	+11.88	
				R.	1847	1	59.1	−0.6		
				J.	1848	4	64.4	−1.6		
				Ja.	1851	5	45 26 62.8	−0.2		
				Ad.			45 27 4.0			
7084	(7.8)	20 25 38	+2.3	M.		17	36 27 46.0		+11.90	0.00
7085	5	20 25 41	+1.9	M.		80	48 28 44.7		+11.91	0.00
7091	6.5	20 26 58	+1.8	M.		52	48 44 44.9		+12.00	−0.04
7100	7	20 27 58	+2.1	Gr.		6	42 42 43.8	+0.3	+12.07	
				J.	1849	4	47.4	−1.5		
				Ja.	1850	4	44.6	−0.2		
				Ad.			42 42 45.7			
7101	7	20 27 59	+2.1	Gr.		6	40 59 32.7	+0.3	+12.07	
				J.	1846	3	37.2	−1.5		
				Ja.	1850	5	35.5	−0.2		
				Ad.			40 59 36.2			
7103	5.6	20 28 25	+2.3	M.		24	34 46 11.3		+12.10	−0.03
7105	6	20 28 20	+1.5	Gr.		6	56 18 6.8	+0.0	+12.10	+0.03
				T.		2	7.9	+0.1		
				J.	1845	5	8.0	−1.4		
				Ad.			56 18 6.8			
7112	6	20 29 17	+2.0	Gr.		6	46 12 40.6	+0.1	+12.16	
				J.	1845	4	42.5	−1.6		
				Ja.	1851	3	41.3	−0.2		
				Ad.			46 12 41.1			
7114	6.7	20 29 31	+2.2	Gr.		6	40 36 48.9	+0.3	+12.17	
				J.	1847	3	51.6	−1.5		
				Ja.	1851	3	50.9	−0.2		
				Ad.			40 36 50.6			
7131	6	20 31 48	+2.4	M.		21	31 4 54.8		+12.33	−0.05
7132	(7)	20 31 49	+2.4	M.		19	31 1 58.5		+12.33	−0.02
7153	7	20 33 12	+1.7	Gr.		6	52 28 54.9	−0.2	+12.43	
				J.	1850	5	55.4	−1.5		
				Ja.	1851	4	55.2	−0.2		
				Ad.			52 28 54.1			
7161	7	20 34 38	+2.0	Br.	1755	2	45 10 12.6	+0.0	+12.53	
				J.	1847	4	13.9	−1.6		
				Ja.	1850	4	12.6	−0.2		
				Ad.			45 10 12.3			
7166	6.7	20 35 21	+1.6	Gr.		6	55 30 34.5	+0.0	+12.58	
				J.	1846	5	33.7	−1.4		
				Ja.	1851	4	32.8	−0.2		
				Ad.			55 30 31.8			
7171	2.1	20 36 38	+2.0	Br.	1755	50	44 46 41.5		+12.66	0.00
				Str.	1830	⊙	41.3	+0.0		
				Arg.	1830	240	41.8	−0.3		
				Airy	1840	74	41.5	−0.1		
				Chal.	1840	188	42.2	−1.2		
				Hend.	1840	71	41.8	−0.6		
				Airy	1845	69	41.5	−0.1		
				J.	1846	29	44 46 42.4	−1.5		

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		h m s	s				° ′ ″	″	″	″
7171	2.1	20 36 38	+ 2.0	Airy	1850	106	44 46 41.4	— 0.1		
				J. 2	1854	5	38.9	— 0.2		
				Airy	1856	43	40.8	— 0.1		
				Ad.			44 46 41.2			
7174	6	20 36 51	+ 2.2	Gr.		6	41 12 48.2	+ 0.3	+ 12.68	
				J.	1846	5	51.2	— 1.5		
				Ja.	1851	4	49.0	— 0.2		
				Ad.			41 12 49.7			
7176	6	20 37 18	+ 1.3	Gr.		6	59 59 38.0	+ 0.2	+ 12.71	
				J.	1846	5	45.6	— 1.2		
				Ja.	1851	3	45.4	— 0.2		
				Ad.			59 59 46.6			
7193	6	20 39 39	+ 1.3	Gr.		6	60 5 40.3	+ 0.2	+ 12.86	
				J.	1847	7	39.0	— 1.2		
				Ja.	1851	4	39.9	— 0.2		
				Ad.			60 5 37.5			
7198	6	20 39 57	+ 2.0	Gr.		6	46 47 11.3	+ 0.1	+ 12.89	
				J.	1844	4	12.5	— 1.6		
				Ja.	1850	4	12.4	— 0.2		
				Ad.			46 47 11.3			
7204	3.2	20 40 30	+ 2.4	M.		86	33 26 39.0		+ 12.92	+ 0.33
				J. 2	1859	7	38.6	— 0.2		
				Ad.			33 26 38.9			
7218	6.7	20 42 16	+ 1.7	Gr.		6	52 29 7.1	— 0.2	+ 13.04	
				J.	1848	4	2.6	— 1.5		
				Ja.	1851	5	52 29 0.5	— 0.2		
				Ad.			52 28 59.2			
7219	7	20 42 30	+ 2.1	Gr.		6	45 3 47.5	+ 0.1	+ 13.06	
				R.	1843	6	47.6	— 0.6		
				J.	1847	4	49.8	— 1.6		
				Ja.	1850	4	48.4	— 0.2		
				Ad.			45 3 47.9			
7233	6.5	20 44 8	+ 2.0	M.		34	45 35 32.0		+ 13.16	— 0.02
7241	5.6	20 45 4	+ 2.1	M.		55	43 31 46.6		+ 13.23	+ 0.12
				J. 2	1857	9	47.5	— 0.2		
				Ad.			43 31 47.0			
7243	6.7	20 45 10	+ 1.9	Gr.		6	50 15 35.4	— 0.1	+ 13.23	
				J.	1845	3	37.6	— 1.6		
				Ja.	1851	4	36.7	— 0.2		
				Ou.	1849	(16)	36.4	+ 0.0		
				Ad.			50 15 36.6			
7246	5	20 46 6	+ 2.6	M.		24	26 34 17.2		+ 13.29	— 0.06
7253	5.6	20 48 16	+ 2.1	M.		65	43 51 17.8		+ 13.44	+ 0.01
				Ja.	1850	4	17.3	— 0.2		
				Ad.			43 51 17.7			
7259	7.8	20 48 54	+ 2.1	M.		18	43 51 8.3		+ 13.48	+ 0.01
				Ja.	1850	3	9.0	— 0.2		
				Ad.			43 51 8.4			
7260	6.7	20 49 6	+ 2.2	Gr.		6	40 10 4.8	+ 0.3	+ 13.49	
				R.	1844	2	2.8	— 0.4		
				J.	1846	5	7.4	— 1.5		
				Ja.	1850	3	5.2	— 0.2		
				Ad.			40 10 5.3			
7268	6	20 51 4	+ 2.0	Br.	1755	1	46 52 38.8		+ 13.62	
				J.	1848	3	45.2	— 1.6		
				Ja.	1850	5	44.0	— 0.2		
				J. 2	1856	6	43.0	— 0.2		
				Ad.			46 52 43.3			

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		h m s	s				° ′ ″	″	″	″
7273	6	20 51 36	+2.1	Gr.		6	44 23 1.9	+0.2	+13.65	
				J.	1843	6	3.2	−1.5		
				Ja.	1850	4	3.8	−0.2		
				Ad.			44 23 2.2			
7274	6.7	20 51 49	+2.0	Br.	1755	1	48 39 18.6		+13.66	
				J.	1848	3	17.6	−1.6		
				Ja.	1850	5	16.7	−0.2		
				Ad.			48 39 16.0			
7290	6	20 53 17	+2.2	M.		4	43 55 27.8		+13.76	+0.08
				Ja.	1851	3	26.9	−0.2		
				J. 2	1856	4	26.3	−0.2		
				Ad.			43 55 26.7			
7294	6	20 53 59	+1.9	Gr.		6	49 54 55.4	−0.1	+13.81	−0.10
				Str.	1823	7	55.7	−0.4		
				T.		3	54.9	+0.1		
				R.	1843	2	57.8	−0.9		
				J.	1843	3	57.4	−1.6		
				Ad.			49 54 56.3			
7297	6.7	20 54 31	+2.3	Gr.		6	39 41 57.2	+0.3	+13.84	
				J.	1849	2	42 8.7	−1.5		
				Ja.	1850	4	5.8	−0.2		
				Ad.			39 42 8.6			
7301	5.6	20 55 2	+2.0	M.		50	46 58 18.4		+13.87	−0.02
7306	6	20 56 16	+2.1	M.		38	45 36 11.9		+13.95	0.00
7317	6	20 57 22	+2.1	Gr.		6	44 14 10.6	+0.2	+14.02	
				J.	1844	3	11.4	−1.5		
				Ja.	1850	4	10.7	−0.2		
				Ad.			44 14 9.9			
7320	6.7	20 57 37	+2.3	M.		17	38 6 7.3		+14.03	+0.03
				J. 2	1855	6	6.4	−0.2		
				Ad.			38 6 6.9			
7332	6	20 59 29	+1.8	Gr.		6	52 43 31.4	−0.2	+14.15	
				J.	1843	3	32.0	−1.5		
				Ja.	1850	4	32.5	−0.2		
				Ad.			52 43 31.2			
7337	6.7	21 0 36	+2.7	Br.	1755	1	37 58 7.7		+14.22	+3.04
				Arg.	1830	33	38 1 55.9	+0.0		
				R.	1846	3	2 43.4	−0.1		
				Ai.	1840	31	2 25.4	+0.5		
				Ai.	1845	36	2 40.8	+0.5		
				J. 2	1855	4	3 11.0	−0.2		
				Ai. 2	1850	35	2 56.4	+0.5		
				Ai. 2	1855	28	3 11.3	+0.5		
				Ad.			38 3 23.9			
7345	5.6	21 1 45	+2.1	M.		71	47 4 58.8		+14.29	−0.01
				Ai. 2	1855	3	59.2	−0.4		
				Ad.			47 4 58.8			
7365	6	21 5 54	+1.9	Gr.		8	52 59 19.7	−0.2	+14.55	−0.06
				T.		2	19.1	+0.0		
				R.	1843	2	21.7	−1.0		
				J.	1844	4	19.8	−1.5		
				Ad.			52 59 18.3			
7387	6.7	21 9 12	+1.5	Gr.		6	59 31 2.7	+0.2	+14.74	−0.03
				T.		1	0.4	+0.2		
				R.	1843	1	30 58.3	−1.4		
				J.	1847	5	31 2.2	−1.2		
				J. 2	1858	3	0.4	+0.1		
				Ad.			59 31 0.0			

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		h m s	s				° ′ ″	″	″	″
7398	4.5	21 11 53	+2.4	M.		85	38 48 20.1		+14.90	+0.03
7401	6	21 13 1	+1.8	Gr.		6	55 12 23.4	+0.0	+14.96	−0.11
				T.		2	23.2	+0.1		
				R.	1844	6	26.2	−1.2		
				J.	1845	4	24.6	−1.4		
				Ad.			55 12 24.2			
7402	5	21 13 12	+2.2	M.		11	43 21 14.7		+14.97	−0.02
				Ja.	1850	4	14.2	−0.2		
				Ad.			43 21 14.5			
7411	5.6	21 14 37	+2.1	Gr.		6	48 54 53.9	+0.0	+15.06	
				J.	1844	3	56.2	−1.6		
				Ja.	1850	4	55.6	−0.2		
				Ad.			48 54 55.3			
7431	6.5	21 17 6	+2.1	Gr.		6	48 47 4.9		+15.20	
				J.	1843	4	11.2	−1.6		
				Ja.	1850	4	9.2	−0.2		
				Ad.			48 47 11.2			
7449	7	21 19 26	+1.3	Pi.			63 37 13.4	+0.4	+15.33	+0.13
				T.		3	17.6	+0.3		
				J.	1847	3	19.0	−0.9		
				Ad.			63 37 19.5			
7455	6	21 20 8	+2.2	M.		14	46 6 17.7		+15.37	+0.03
7461	6.5	21 21 28	+2.6	M.		19	26 59 47.0		+15.44	+0.02
				J. 2	1855	5	47.5	−0.2		
				Ad.			26 59 47.1			
7462	6.5	21 21 37	+2.4	T.			36 30 19.2	+0.7	+15.45	−0.02
				Ad.			36 30 19.9			
7465	6	21 22 7	+2.6	T.			31 36 33.5	+0.6	+15.48	+0.09
				Ad.			31 36 34.1			
7469	7	21 22 20	+2.2	Pi.			45 48 13.2	+0.0	+15.50	−0.05
				T.			13.0	+0.2		
				Ai.	1847	2	15.8	−0.3		
				J.	1850	4	16.4	−1.6		
				Ad.			45 48 15.7			
7480	5	21 24 15	+2.2	M.		62	45 55 13.0		+15.60	+0.11
				J. 2	1857	5	12.3	−0.2		
				Ai. 2	1855	3	12.3	−0.3		
				Ad.			45 55 12.8			
7488	6.7	21 26 31	+2.0	Gr.		6	51 34 17.8	−0.2	+15.73	
				J.	1847	4	23.0	−1.5		
				Ja.	1850	4	22.1	−0.2		
				Ou.	1849	(16)	22.0	+0.0		
				Ad.			51 34 22.8			
7501	7	21 28 1	+2.2	J.	1850	2	45 13 48.6	−1.6	+15.80	+0.06
				Ja.	1850	4	48.1	−0.2		
				Ad.			45 13 47.5			
7503	4.5	21 28 41	+2.2	M.		51	44 58 11.0		+15.84	−0.10
7505	5	21 29 1	+2.4	M.		35	37 54 12.4		+15.86	+0.10
				J. 2	1858	2	13.7	−0.2		
				Ad.			37 54 12.5			
7512	6.7	21 29 36	+2.1	Gr.		6	51 4 15.9	−0.2	+15.89	
				J.	1845	3	17.9	−1.5		
				Ja.	1850	3	16.9	−0.2		
				Ou.		(16)	17.1	+0.0		
				Ad.			51 4 17.1			
7521	5	21 31 18	+2.4	M.		33	39 46 54.4		+15.98	+0.01
7524	6.7	21 32 6	+2.4	Gr.		6	38 41 1.3	+0.2	+16.02	−0.14
				T.		3	38 41 1.3	+0.7		

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		h m s	s				° ′ ″	″	″	″
7524	6.7	21 32 6	+2.4	J.	1846	3	38 41 4.3	−1.4		
				Ad.			38 41 3.4			
7533	7	21 33 25	+1.6	Gr.		3	61 39 49.9	+0.4	+16.09	
				T.		4	55.2	+0.2		
				J.	1843	3	55.8	−1.0		
				J. 2	1857	4	55.5	+0.2		
				Ad.			61 39 56.2			
7542	5.6	21 34 8	+1.6	M.		55	61 26 48.4		+16.14	0.00
7544	6.5	21 34 39	+2.3	M.		30	42 38 6.6		+16.15	+0.02
				Ai. 2	1855	10	6.3	+0.3		
				Ad.			42 38 6.6			
7554	6	21 35 54	+2.4	M.		37	40 9 59.6		+16.22	−0.06
7560	5.4	21 37 5	+2.1	M.		113	50 32 50.1		+16.28	0.00
7565	5.6	21 37 26	+2.4	M.		27	40 30 43.7		+16.30	+0.02
7571	4	21 38 16	+2.7	M.		33	24 59 57.0		+16.34	+0.03
7584	7	21 39 33	+2.7	Lal.	1794	2	24 56 11.8	−1.6	+16.41	−0.11
				R.	1843	1	3.6	+0.6		
				J. 2	1854	3	6.1	−0.2		
				Ad.			24 56 4.9			
7586	7	21 39 59	+2.7	M.		8	24 54 44.8		+16.43	+0.04
				J. 2	1857	2	42.2	−0.2		
				Ad.			24 54 43.9			
7602	6	21 42 28	+2.5	Gr.		6	38 18 7.7	+0.2	+16.55	
				J.	1846	3	12.0	−1.4		
				Ja.	1850	4	10.2	−0.2		
				Ad.			38 18 11.2			
7607	5	21 43 37	+2.6	M.		34	29 31 10.1		+16.61	−0.02
7612	6.7	21 45 3	+2.1	Gr.		6	52 2 24.0	−0.2	+16.68	
				J.	1845	4	25.4	−1.5		
				Ja.	1850	4	23.3	−0.2		
				Ou.		(3)	23.0	+0.0		
				Ad.			52 2 23.3			
7614	6	21 45 15	+2.5	Gr.		6	38 52 37.9	+0.2	+16.69	
				J.	1847	4	41.1	−1.4		
				Ja.	1850	4	39.8	−0.2		
				Ad.			38 52 40.2			
7637	7	21 48 23	+2.1	M.		15	53 (19 53.7)		+16.84	−0.05
7646	6.7	21 50 33	+2.1	Gr.		12	52 34 30.2	−0.2	+16.94	
				J.	1845	4	31.6	−1.5		
				Ja.	1850	4	32.2	−0.2		
				Ad.			52 34 31.0			
7668	6.7	21 54 40	+2.0	M.		15	56 59 2.3		+17.13	−0.02
				J. 2	1857	4	3.6	+0.0		
				Ad.			56 59 2.8			
7679	6.7	21 56 57	+2.5	Gr.		6	42 8 3.9	+0.3	+17.24	
				J.	1846	3	7.8	−1.5		
				Ja.	1850	4	5.3	−0.2		
				Ad.			42 8 6.3			
7683	6	21 57 20	+2.0	M.		33	57 19 14.8		+17.25	−0.01
7705	6.5	22 0 18	+2.4	Gr.		6	44 19 46.1	+0.2	+17.39	−0.10
				T.		4	47.3	+0.4		
				J.	1849	3	48.7	−1.5		
				J. 2	1857	2	47.3	−0.2		
				Ad.			44 19 47.5			
7718	6.7	22 2 25	+2.0	Gr.		6	58 9 14.2	+0.1	+17.47	−0.04
				T.		2	13.0	+0.1		
				R.	1843	1	13.8	−1.3		
				Ai.	1843	6	58 9 12.4	−0.4		

B. A. C.	Mag.	α 1859.0.	Annual Variation.	Authority.	Mean Year.	No. Obs.	δ 1859.0.	Systematic Correction.	Precession.	Proper Motion.
		h m s	s				° ′ ″	″	″	″
7718	6.7	22 2 25	+ 2.0	J.	1844	3	58 9 14.5	— 1.3		
				Ad.			58 9 11.8			
7721	(5.6)	22 2 59	+ 2.7	M.		43	32 29 6.4		+ 17.50	0.00
7727	6.7	22 3 6	+ 2.4	Gr.		6	47 14 40.9	+ 0.0	+ 17.51	
				Ai.	1843	7	41.1	— 0.4		
				J.	1845	3	41.0	— 1.6		
				Ja.	1850	4	41.8	— 0.2		
				Ad.			47 14 40.4			
7731	4	22 3 44	+ 2.7	M.		42	32 29 15.3		+ 17.53	0.00
7736	7	22 3 50	+ 2.0	Pi.			58 36 12.0	+ 0.3	+ 17.53	+ 0.01
				J.	1847	3	13.0	— 1.3		
				J. 2	1856	1	12.0	+ 0.1		
				Ad.			58 36 11.7			
7737	7	22 3 55	+ 2.5	Gr.		6	42 29 42.1	+ 0.3	+ 17.54	— 0.01
				T.		4	45.0	+ 0.5		
				J.	1843	3	45.1	— 1.5		
				Ai. 2	1856	2	42.0	+ 0.3		
				Ad.			42 29 44.3			
7743	6.7	22 5 12	+ 2.5	Gr.		6	42 20 16.7	+ 0.3	+ 17.60	
				J.	1845	5	19.5	— 1.5		
				Ja.	1850	4	17.2	— 0.2		
				Ad.			42 20 17.9			
7755	6.5	22 6 44	+ 2.0	M.		31	58 43 9.7		+ 17.65	— 0.06
				J. 2	1857	4	10.1	+ 0.1		
				Ad.			58 43 9.7			
7765	5	22 7 50	+ 2.6	Gr.		6	39 0 58.6	+ 0.3	+ 17.71	
				Arg.	1830	8	60.6	— 0.1		
				T.		5	60.8	+ 0.6		
				J.	1850	2	60.8	— 1.5		
				Ad.			39 0 59.8			
7770	6	22 8 49	+ 2.5	Gr.		6	42 15 20.5	+ 0.3	+ 17.75	
				J.	1845	3	22.4	— 1.5		
				Ja.	1850	4	20.8	— 0.2		
				Ad.			42 15 20.8			
7777	5.4	22 9 50	+ 2.6	M.		42	37 2 52.3		+ 17.78	+ 0.01
7787	7	22 13 11	+ 2.3	Gr.		6	51 57 1.1	— 0.2	+ 17.91	
				J.	1842	5	4.1	— 1.5		
				Ja.	1850	4	2.1	— 0.2		
				Ou.	1849	(7)	2.5	+ 0.0		
				Ad.			51 57 2.9			
7820	5	22 18 48	+ 2.4	M.		37	48 45 44.2		+ 18.13	— 0.03
7824	6.7	22 19 25	+ 2.4	Gr.		6	50 32 21.6	— 0.1	+ 18.14	
				T.		4	24.0	+ 0.1		
				J.	1845	3	25.5	— 1.6		
				Ou.	1849	(18)	25.1	+ 0.0		
				Ad.			50 32 25.5			
7825	7.8	22 19 44	+ 2.4	Gr.		5	49 41 9.1	— 0.1	+ 18.15	
				T.		4	11.6	+ 0.1		
				J.	1846	3	11.7	— 1.6		
				Ad.			49 41 10.3			
7845	5	22 23 41	+ 2.5	M.		32	46 59 9.8		+ 18.31	— 0.01
				J. 2	1859	1	11.6	— 0.2		
				Ad.			46 59 9.9			
7850	5	22 24 24	+ 2.6	M.		67	42 24 5.9		+ 18.34	0.00
7855	4	22 25 29	+ 2.5	M.		152	49 33 29.8		+ 18.37	— 0.01
				J. 2	1857	2	29.9	— 0.1		
				Ad.			49 33 29.8			
7858	6	22 26 12	+ 2.6	Gr.		6	39 3 20.7	+ 0.3	+ 18.40	

B. A. C.	Mag.	α 1859.0.	Annual Variation.	Authority.	Mean Year.	No. Obs	δ 1859.0.	Systematic Correction.	Precession.	Proper Motion.
		h m s	s							
7858	6	22 26 12	+2.6	J.	1846	3	39° 3′ 21″.1	−1″.5		
				Ja.	1850	4	20.8	−0.2		
				Ad.			39 3 19.7			
7879	7	22 29 35	+2.7	M.		16	38 53 56.7		+18″.51	−0″.14
				J. 2	1859	3	56.9	−0.2		
				Ad.			38 53 56.7			
7880	6	22 29 36	+2.7	M.		66	38 54 21.1		+18.51	+0.01
				J. 2	1858	1	20.5	−0.2		
				Ad.			38 54 21.1			
7894	6.7	22 32 12	+2.6	Gr.		6	44 27 2.9	+0.2	+18.60	
				T.		3	3.7	+0.4		
				J.	1845	4	6.3	−1.5		
				Ad.			44 27 5.5			
7906	5	22 34 20	+2.6	M.		68	43 32 27.4		+18.67	0.00
				J. 2	1857	3	28.0	−0.2		
				Ai. 2	1857	12	28.1	+0.1		
				Ad.			43 32 27.6			
7913	7	22 35 1	+2.6	Gr.		6	44 16 19.6	+0.2	+18.69	
				T.		2	21.0	+0.4		
				Ai.	1841	1	20.9	+0.0		
				J.	1845	3	22.9	−1.5		
				Ad.			44 16 22.0			
7917	6	22 35 18	+2.7	Gr.		6	40 48 35.6	+0.3	+18.70	
				J.	1847	4	40.4	−1.5		
				Ja.	1850	4	38.9	−0.2		
				Ad.			40 48 39.6			
7948	6	22 39 55	+2.6	Gr.		6	43 48 10.8	+0.2	+18.84	
				Ai.	1843	5	12.9	+0.0		
				J.	1846	4	14.2	−1.5		
				Ja.	1850	4	11.4	−0.2		
				Ad.			43 48 13.0			
7950	6	22 40 12	+2.6	Gr.		12	45 28 28.6	+0.1	+18.85	
				T.		3	28.2	+0.2		
				J.	1846	6	30.1	−1.6		
				J. 2	1857	3	29.0	−0.2		
				Ad.			45 28 28.6			
7972	6	22 45 41	+2.7	M.		29	42 33 49.9		+19.01	+0.01
				J. 2	1859	5	51.0	−0.2		
				Ai. 2	1855	2	49.5	+0.2		
				Ad.			42 33 50.1			
7983	6	22 47 22	+2.7	Gr.		6	44 0 0.5	+0.2	+19.06	
				J.	1845	3	2.9	−1.5		
				Ja.	1850	4	1.7	−0.2		
				Ad.			44 0 1.7			
7994	6	22 49 58	+2.7	M.		32	40 51 8.0		+19.13	+0.01
7995	6	22 50 15	+2.6	Gr.		6	48 58 54.0	+0.0	+19.13	
				J.	1845	5	54.1	−1.6		
				Ja.	1850	4	53.2	−0.2		
				Ad.			48 58 52.1			
8023	4.3	22 55 26	+2.7	M.		102	41 34 8.7		+19.26	−0.03
				Ai. 2	1855	1	8.6	+0.3		
				Ad.			41 34 8.7			
8028	6	22 56 7	+2.7	M.		26	41 59 59.9		+19.28	+0.02
8032	2.3	22 56 56	+2.9	M.		115	27 19 8.4		+19.30	+0.15
				J. 2	1857	5	7.8	−0.2		
				Ad.			27 19 8.3			
8036	5.6	22 57 52	+2.7	M.		49	49 17 10.2		+19.32	+0.16
				J. 2	1858	1	49 17 8.6	−0.2		

B. A. C.	Mag.	α 1859.0.	Annual Variation.	Authority.	Mean Year.	No. Obs.	δ 1859.0.	Systematic Correction.	Precession.	Proper Motion.
		h m s	s				° ′ ″			
8036	5.6	22 57 52	+ 2.7	Ad.			49 17 10.1			
8054	5.6	23 0 40	+ 2.5	M.		42	58 39 28.2		+ 19.39	— 0.02
8056	6.7	23 0 51	+ 2.7	M.		8	45 18 20.6		+ 19.39	
				Ja.	1850	3	22.2	— 0.2		
				Ad.			45 18 21.2			
8058	6	23 1 13	+ 2.7	M.		31	45 37 33.7		+ 19.40	— 0.05
8059	6	23 1 22	+ 2.7	M.		36	48 31 41.2		+ 19.40	+ 0.12
				J. 2	1857	4	41.4	— 0.2		
				Ad.			48 31 41.2			
8075	6	23 3 43	+ 2.5	M.		40	58 34 5.2		+ 19.45	— 0.02
				J. 2	1857	3	7.4	+ 0.1		
				Ad.			58 34 5.6			
8076	6	23 3 57	+ 2.8	M.		42	42 47 14.8		+ 19.46	— 0.18
				J. 2	1856	4	15.2	— 0.2		
				Ad.			42 47 14.9			
8082	5	23 6 6	+ 2.7	M.		106	48 38 10.7		+ 19.50	+ 0.08
8091	(7)	23 8 5	+ 2.9	Lal.	1795	1	27 18 23.0	— 1.5	+ 19.54	
				Ja.	1850	4	14.8	— 0.2		
				Ad.			27 18 13.5			
8097	(6)	23 8 53	+ 2.9	M.		22	27 28 47.5		+ 19.56	0.00
8099	(8)	23 9 11	+ 2.9	Pi.			27 27 33.4	— 1.2	+ 19.57	— 0.08
				T.		1	28.9	+ 0.5		
				R.	1841	1	30.2	+ 0.5		
				Ad.			27 27 28.4			
8110	6	23 10 39	+ 2.8	Gr.		6	44 23 53.1	+ 0.2	+ 19.59	
				J.	1844	4	52.6	— 1.5		
				Ja.	1850	4	52.0	— 0.2		
				Ad.			44 23 50.6			
8114	5.6	23 11 13	+ 2.8	M.		55	48 14 42.8		+ 19.60	0.00
8118	6	23 11 48	+ 2.8	M.		27	41 0 14.2		+ 19.61	— 0.02
8120	6.7	23 12 24	+ 2.8	Gr.		6	44 22 0.3	+ 0.2	+ 19.63	
				J.	1845	3	1.5	— 1.5		
				Ja.	1850	3	0.3	— 0.2		
				Ad.			44 21 59.8			
8125	6	23 12 56	+ 2.8	M.		27	47 51 8.6		+ 19.64	+ 0.06
8126	6.7	23 13 5	+ 2.8	M.		25	47 36 30.8		+ 19.64	+ 0.03
				J. 2	1857	1	32.7	— 0.2		
				Ad.			47 36 30.9			
8128	6	23 13 10	+ 2.8	M.		27	41 18 24.8		+ 19.64	+ 0.03
8135	6	23 14 4	+ 2.8	J.	1847	2	43 20 46.2	— 1.5	+ 19.66	
				Ja.	1850	4	44.7	— 0.2		
				Ad.			43 20 44.6			
8153	5?	23 16 16	+ 2.6	M.		12	59 21 38.4		+ 19.69	— 0.01
				Ja.	1850	5	39.0	— 0.2		
				Ad.			59 21 38.5			
8156	7.8	23 16 52	+ 3.0	M.		27	31 45 20.9		+ 19.70	— 0.05
				J. 2	1857	1	23.9	— 0.2		
				Ad.			31 45 21.1			
8159	6	23 17 58	+ 2.9	M.		22	31 36 38.4		+ 19.72	0.00
				J. 2	1857	4	38.6	— 0.2		
				Ai. 2	1854	5	38.8	+ 0.6		
				Ad.			31 36 38.6			
8171	6	23 20 20	+ 2.9	M.		41	42 8 10.4		+ 19.76	+ 0.03
8188	5	23 23 32	+ 2.8	Gr.		12	57 46 17.7	+ 0.1	+ 19.81	+ 0.02
				T.		5	19.4	+ 0.1		
				R.	1843	5	18.0	— 1.3		
				Ai.	1841	44	18.9	— 0.4		
				J.	1844	4	57 46 20.0	— 1.3		

B. A. C.	Mag.	α 1859.0.	Annual Variation.	Authority.	Mean Year.	No. Obs.	δ 1859.0.	Systematic Correction.	Precession.	Proper Motion.
		h m s	s				° ′ ″			
8188	5	23 23 32	+2.8	Ad.			57 46 18.9			
8195	6	23 24 22	+2.9	M.		43	38 27 43.3		+19.81	−0.08
				J. 2	1859	4	43.5	−0.2		
				Ad.			38 27 43.3			
8211	6	23 27 40	+3.0	M.		17	32 43 3.6		+19.86	+0.04
8224	4	23 30 40	+2.9	M.		139	45 41 39.4		+19.89	−0.45
				J. 2	1857	1	39.5	−0.2		
				Ad.			45 41 39.4			
8229	4	23 31 14	+2.9	M.		89	42 29 17.6		+19.90	+0.03
				Ai. 2	1856	5	15.3	+0.3		
				Ad.			42 29 17.4			
8237	4	23 33 28	+2.9	M.		77	43 33 14.0		+19.92	+0.01
8245	6.7	23 35 19	+2.9	Gr.		7	44 12 38.3	+0.2	+19.93	
				Ai.	1840	6	39.8	+0.0		
				J.	1846	4	40.5	−1.5		
				Ja.	1850	4	39.4	−0.2		
				Ad.			44 12 39.8			
8268	5	23 40 11	+2.9	M.		79	57 52 0.0		+19.98	+0.06
8282	6	23 42 17	+2.9	Br.	1755	1	58 10 51.3		+19.99	−0.02
				J.	1845	4	49.0	−1.3		
				Ja.	1850	4	48.9	−0.2		
				Ad.			58 10 47.6			
8284	6	23 42 31	+3.0	M.		20	28 3 29.3		+19.99	+0.04
8324	5	23 50 35	+3.0	M.		37	24 21 28.4		+20.04	−0.04
8326	6	23 50 59	+3.0	Gr.		6	49 38 58.8	−0.1	+20.04	+0.09
				T.		4	39 5.0	+0.1		
				J.	1845	3	9.1	−1.6		
				Ad.			49 39 11.0			
8338	7.8	23 53 34	+3.0	M.		13	61 23 32.6		+20.05	−0.04
8345	6.7	23 54 32	+3.0	Gr.		6	41 34 56.8	+0.3	+20.05	
				Ai.	1843	29	55.7	+0.3		
				J.	1846	4	56.4	−1.5		
				Ja.	1850	4	55.7	−0.2		
				Ad.			41 34 55.2			

NOTE. — The declinations of the Radcliffe Catalogue, received since these computations were made, have already been corrected by systematic corrections very nearly the same as those given by Mädler. The results marked J. in the preceding Catalogue, from the original volumes, have not these corrections.

The Radcliffe Catalogue contains, as it seems, the results of some of the observations designated by J. 2 in the preceding list; and also, as I suppose, the results of Sub Polo observations. These latter I have generally omitted, as our stars would be affected Sub Polo by the uncertainty of refraction.

The reductions to 1845.0 in the Radcliffe Catalogue seem to contain proper motion in some cases. The method which I have employed did not admit of this in case of stars not contained in Mädler's list.

I find a discrepancy between Mädler's position of the stars 4789 and 7637, and modern observations. The latter indicate that the declinations for 1859 are as follows: —

4789 52° 30′ 13″.1 7637 53° 20′ 1″.7

XI.

The Lumbar Enlargement of the Spinal Cord.

By JOHN DEAN, M. D.

(*Communicated through* Dr. Jeffries Wyman, *November* 14, 1860.)

I propose, in the following paper, to notice a few points in regard to the structure of the spinal cord, confining myself chiefly to a description of the course of the fibres forming the nerve-roots, as they pass through the white and gray substances to their final union with nerve-cells, discussing somewhat at length the relation which nerve-cells and fibres sustain in the cord.

In drawing up the descriptive details of this memoir I have restricted them chiefly to the lumbar region in some of the higher vertebrates, lest any deductions I might attempt to establish should be embarrassed by the necessity of comparing observations made upon portions of the cord differing somewhat in structure.

The division commonly made in the substance of the cord into gray and white matter, or into vesicular and fibrous, seems to be tenable only when we state the difference between them to consist in the presence of true nerve-cells in the gray or vesicular, while they are absent in the white or fibrous substance. This distinction seems to me the only correct one, for I am fully satisfied that the so-called *cells of the white substance*, described by Stilling and others, are nothing more than cells belonging to the connective tissue, or, as sometimes occurs, true nerve-cells which have been isolated from the gray substance by the plane of section. Bidder* remarks on the situation of cells evidently connected with the cornua, that " they are sometimes quite encircled by the white substance, in which rare case this substance forms but a very small partition separating them from the gray." This every observer will have noticed, and I have often in longitudinal sections found such cells quite isolated, which I should have considered as belonging to the white substance, had not the section, following a slightly

* Bidder and Kupffer, Untersuch. über die Textur d. Rückenmarks. Leipzig, 1857.

oblique plane, run fully into the cornu lower down. I have never met with true nerve-cells (cells giving off distinct nerve-tubes) in any other situation in the white substance.

My own observations are entirely in agreement with the description which J. L. Clarke* has given of the connective tissue. I have, however, frequently noticed in the cords of adult animals that a few of the cells were still persistent, especially in the vicinity of the posterior cornua, where I have several times seen quite large cells sending out fine processes continuous with the connective tissue. The view which Clarke has taken of the possible relation between connective and true nerve-tissue seems very valuable; for I have long been satisfied of the impossibility of fully distinguishing, with our present means, between these two tissues, which seem to run into each other so closely as to suggest very strongly the important question, "whether there is any actual and essential difference between them, or whether the connective tissue of the cord be intermediate in its nature, passing on the one hand into *nerve* tissue, and on the other into pia mater."† Every observer who has in his possession moderately transparent specimens must be able to satisfy himself of the entire incompleteness of the views of Bidder and others, in whose opinion the greater part of the gray substance consists of connective tissue.

The gray substance is composed of nerve-cells, connective tissue, and nerve-fibres running in various directions, transverse, oblique, and longitudinal.

The form of the gray substance has been so fully and faithfully described and figured by Clarke‡ and Stilling,§ that I shall proceed at once to consider: —

I. *The Nerve-Cells, their Situation, and the Relation which Cells and Fibres bear to each other.*

(A.) *The Nerve-Cells.* — The form of these has been fully figured and described by Clarke, Kölliker, R. Wagner, Stilling, and many others. The cells are subject to great variation, the apparent form, size, and number of processes depending, without doubt, very much on the direction of the plane of section with respect to the situation of the cell. With regard to the distinctions which Jacubowitsch‖ has founded on the size of the cells, dividing them into motor, sensitive, and sympathetic, according to their relative dimensions, I fully agree with Stilling as to the absolute impossibility of making any such classification in our present state of knowledge, and a glance at any of the

* Philos. Trans., 1859, Pt. I. p. 441. † Ibid., p. 442.

‡ Philos. Trans., 1851, 1853, 1859.

§ Neue Untersuchungen über d. Bau d. Rückenmarks. Cassel, 1850–59.

‖ Bulletin de l'Académie de St. Petersburg. 1856.

figures which accompany this paper will show cells which, according to Jacubowitsch, should be sensitive, in the anterior cornua, and large or motor cells in the posterior cornua.

The nerve-cell appears to be simply an enlargement of the axis cylinder, containing a granular substance and a nucleus. Sometimes by the use of a power of 700 – 900 diameters I have thought that I detected a cell wall from which the coagulated cell contents seemed shrunken away. With the description which Stilling gives of the minute structure of cell and fibre I cannot at all agree, being convinced, from what little investigation I have been able to make, that the so-called *elementary tubuli* are produced artificially by the coagulating action of chromic acid; and Clarke has recently shown that these appearances may be produced at will in fresh nerve fibre, either by coagulation or mechanical agency.*

(B.) *The Groups of Nerve-Cells, and their Situations.*—The groups of cells situated in the anterior cornua have already been fully described by Clarke, Stilling, and various other authors. I shall confine my own observations entirely to the cells of the posterior cornua, about which greater difference of opinion exists. Bidder and his followers deny the existence of any true nerve-cells in the posterior cornua; in only one case did they observe a large nucleated cell with several processes in the gelatinous substance of the cord of a dog.† Figs. 6, 7 show the relative size and frequency of these cells, and as these two figures are drawn to the same scale as Figs. 4, 5, from the anterior cornua, they will serve for comparison; they are all drawn from the lumbar enlargement of the calf. For convenience of description, I shall adopt Clarke's division of the posterior cornu into *cervix* and *caput cornu*, the *caput* being the broad expanded portion of the cornu, the *cervix* the remainder of the cornu as far forwards as the central canal. My observations on the cells of the posterior cornu, which were mostly made before I had seen Clarke's recent paper (1859),

* Observations on the Structure of Nerve-Fibre. Quart. Jour. of Microscopical Science, January, 1860.

† That other observers have differed from them, Bidder and Kupffer attempt to explain by the somewhat singular hypothesis, that on the one hand cells of connective tissue are liable to be mistaken for nerve-cells, and also preparation by chromic acid "does not preclude the possibility, that, in cutting the section, cells should be torn from their natural situation, and transported to a locality where they do not belong or are not expected to appear." (*Loc. cit.*, p. 68.) This latter supposition, even if we could conceive of the possibility "*that, in cutting the section,*" cells could be *stolen, and displayed with their processes spread out by the razor*, might be set entirely at rest by making the section from behind forwards, in which case we might certainly infer that all the cells of the posterior portion belonged where they were seen, and the only inference it seems possible to draw is that the preparations of the Dorpat school are not sufficiently transparent for the display of these cells, which certainly require more delicate preparation than is necessary for the cells of the anterior cornua.

are so entirely in agreement with his statements in all important particulars that I shall only notice some of the principal points. The large cells of the gelatinous substance, which Clarke has described as occurring only in the fibrous band constituting the border of the *substantia gelatinosa*, are quite apparent in longitudinal sections, disposed at nearly regular intervals, usually in a single line just above each other, close to the entrance of the posterior roots into the gray substance, seeming to constitute a regular column connected with the posterior roots. With respect to the smallest cells, as well those of the whole posterior cornu as the *substantia gelatinosa*, I have not been able entirely to satisfy myself. Many of the smaller cells belong undoubtedly to the connective tissue, many are merely fragments of larger cells, and it is not improbable that some may be true nerve-cells still in process of development. Fusiform cells* are often met with in the gelatinous substance, and are quite abundant in all parts of the posterior cornu, being frequently found in longitudinal sections. In the central portion of the *caput* the cells are mostly small, though large ones are occasionally seen, and just at the junction between *cervix* and *caput* large cells occur which are sometimes quite thrust out into the white substance, embracing the longitudinal white fibres on all sides with their processes; in some few sections I have met with several cells in this position, forming by their processes quite an intricate network out among the white fibres. In the *cervix* many large cells are met with, together with numbers of smaller size, and here cells are found more or less grouped together, belonging to Clarke's *posterior vesicular columns;* for I cannot agree with Stilling that these cells disappear entirely in the greater part of the lumbar enlargement.†

(C.) *The Relation which Cells and Fibres bear to each other.* — This subject I shall treat under the following heads: — (*a.*) *The Connection of the Nerve-Cells with each other;* (*b.*) *The Connection of the Cells with the Anterior and Posterior Roots;* (*c.*) *The Connection of the Cells with the Longitudinal or White Fibres.*

(*a.*) *The Connection of the Nerve-Cells with each other.* — Schröder van der Kolk ‡

* Figured by Clarke, Stilling, and Kölliker.

† Stilling states, in opposition to Clarke, that the posterior vesicular columns, — "(1.) Do not form uninterrupted columns through the entire length of the cord. (2.) They do not enlarge in diameter in the lumbar and cervical enlargements, but disappear entirely in the greater part of these enlargements. (3.) Their greatest diameter is in the dorsal region between these enlargements." In the dorsal region, according to my own observations, they seem to be collected into a compact group, completely circumscribed by a band of fibres, while in the lumbar region they are scattered over a very considerable space, the cells by no means entirely disappearing, however, even in the lower part of the lumbar enlargement. Clarke in his last paper, Philos. Trans. 1859, has somewhat modified his earlier statements.

‡ Bau und Functionen der Medulla Spinalis und Oblongata. Braunschweig, 1859.

describes and figures, for the most part very truthfully, the communications between cells by means of longer or shorter fibres. He states that two cells are often united by more than one fibre, but so far as my own observations reach this is exceedingly rare. He seems to infer that cells of the posterior cornua are also connected, though he does not mention ever having seen this. Lenhossék * speaks of the cells as being multipolar, and connected together in a continuous chain "from the apex of the *conus medullaris* to the inmost structure of the brain"; he figures the union of several cells from the cervical enlargement of the human cord. Bidder and Kupffer † notice the same fact; they were also able to make out cell connections in longitudinal sections. Stilling ‡ agrees with the authors cited above, considering these cell connections, however, as independent of those which he believes established between all the cells by the *elementary tubuli*. Both Stilling and Schröder van der Kolk describe the cell-process as bifurcating, distant cells being connected together by this first division, or by means of still further ramification. Stilling carries this division of the cell-process much further than Van der Kolk, making the branches split again and again, till they are reduced to the finest *elementary tubuli*. My own observations agree in this respect much more nearly with the figure and description of Clarke; § his statement that the cell-processes "divide and subdivide into smaller branches, so that the space between them appears to be occupied by a minute network of the most delicate fibrils," is entirely correct, if we take for granted that Clarke would not carry the splitting so far as to reduce the cell-process to *elementary tubuli*, which appears to be a just inference from his criticisms on Stilling's views. ‖ I have uniformly seen the cells connected by fibres *never smaller* than the axis cylinder of the finest nerve-fibres of the white substance, being usually (measured at a sufficient distance from the cell for the diameter to be uniform) about .0001 – .00025″ in diameter.

That *some* cells are connected together by their processes, as described by the authors cited above, admits of no doubt; the results of my own observations, made on the cords of the rabbit, calf, sheep, cat, and ox, admitting of the comparison of many hundred sections, have been very uniform, establishing beyond any doubt connections between *some* cells in every section of average clearness. These connections are by no means so easy to be made out that careful study is not needed to satisfy the observer; a cell-process rarely runs its course on the same plane, so that constant change of focal adjustment is necessary, and the fibres interlace and cross in such confusion, that much

* Neue Untersuch. üb. d. Feineren Bau d. Centralen Nervensystems, (Wien, 1858,) p. 7.

† *Op. cit.*, p. 63.

‡ Neue Untersuch., p. 928.

§ Philos. Trans., 1851, Pl. XXV. Fig. 15.

‖ Quart. Jour. of Microscopical Science, 1860.

patience, and objectives of large angular aperture and very clear definition, ranging in power from 200 to 700 diameters, are constantly needed to satisfy the observer of the truth of what is seen with lower powers. Usually a power of about 120 diameters is best calculated for this study, and with this most of my drawings were made; but sometimes as high a power as 700 is required for the complete resolution of the course of fibres, and none of my drawings were made until the preparation had been carefully studied with high objectives.

Figs. 1, 2, 3, 4, from transverse sections from the anterior cornu, Fig. 5, from a longitudinal section through the same cornu, and Figs. 6 and 7, representing respectively longitudinal and transverse sections from the posterior cornu, may be referred to as exhibiting the different modifications of cell-connection. Sometimes, as at *d*, Fig. 1, the cells are joined by a short, thick fibre; in other cases the process is much longer and usually somewhat thinner (Fig. 1, *c*, and Fig. 2, *d d*); Figs. 3 and 4 give very good examples of both these forms; Fig. 7 shows that these connections are equally met with in the posterior cornua, though they are more difficult to make out here, owing to the finer nature and more complex arrangement of the fibres. Longitudinal sections (Figs. 5 and 6) show chiefly the longer mode of cell-connection; this is especially the case in Fig. 5, from the anterior cornu, where the arrangement of fibres is much easier to make out than in the posterior parts of the cord.

I should, however, state my views very unfairly, did I not urge the great necessity of caution in regard to this question of cell-connection. We are able beyond doubt to see that *some* cells are connected together by their processes, but we are at present by no means able to state, with Lenhossék, that all the cells are connected in a continuous chain; indeed, we have much reason for thinking quite otherwise, the result of a year's observation, principally in this single direction, having convinced me that the undoubted examples of cell-connection, *seen* even in the most favorable specimens, are *exceptional* rather than constant. In a question bearing on all our ideas of nervous conduction so strongly as this does, the necessity for caution in everything like *inference* cannot be too strongly insisted upon.

(*b.*) *The Connection of the Cells with the Anterior and Posterior Roots.*—That fibres of the anterior roots have their origin in cells of the anterior cornu has been fully established by Bidder,* Schilling,† R. Wagner,‡ Stilling,§ and Schröder van der Kolk,‖

* Bidder and Kupffer, Untersuch. über d. Text. d. Rückenmarks, (Leipzig, 1857,) p. 95.

† De Medullæ Spinalis Text. Dorpat, 1852.

‡ Neurolog. Untersuchungen.

§ Neue Untersuchungen.

‖ *Op. cit.*, p. 37.

the only difference between these authors being one of degree; Stilling maintaining that *some* only of the fibres constituting the anterior roots arise from cells within the cord, the remainder being direct continuations of the posterior roots; on the other hand, Bidder and Schröder van der Kolk consider the cells of the anterior cornua the sole origin of the anterior roots. Clarke in his more recent papers acknowledges the cells as a partial source of origin for the roots; he says, "I have seen the processes of the nerve-cells extend so frequently into the anterior roots, that there can be no doubt that some of the latter arise from them."* He also describes and figures this as occurring very frequently in the lumbar and cervical region of the tortoise. That the anterior roots are derived *partly at least* from nerve-cells, is beyond doubt; the principal groups of cells in the anterior cornua are however usually situated at some distance from the border of the gray substance, so that it is often quite difficult to trace these connections; but I have sometimes (though I must admit very rarely) succeeded in tracing, in the cords of small animals, fibres derived from cell processes, not only *into* the bundle of anterior roots, *but quite to their exit from the cord.* This is shown as seen in the cord of the rabbit (Fig. 1, *a'*). Fig. 4 shows a group of cells sending their processes into the anterior roots at *A*; the four cells marked *b* are connected with the bundle of anterior roots by very long, slender processes, and are also connected with each other and with neighboring cells. This is a very interesting group, though, owing to its lying at some distance within the boundary of the cornu, comparatively few of the processes could be traced out into the bundle of roots. Fig. 5 is from a longitudinal section through the anterior cornu; the group of cells is situated quite near the white substance, and a number of cell processes can be traced out into the bundles of fibres forming the anterior roots (Fig. 5, *b*, *b*). Schröder van der Kolk, Bidder, and others, (as stated above,) consider the anterior roots as arising without exception from the cells of the anterior cornua. With this view I cannot agree, for, as it must be acknowledged that at present the fibres we are able to trace with any certainty from cells to the anterior roots are rather the exceptions than the rule, this theory is evidently more the result of inference than of direct observation. On the other hand, we have the fact, the evidence of which I shall discuss further on, that part of the anterior roots are direct continuations of the posterior roots without the intervention in the cord of *any* cells.†

* Philos. Trans., 1859, p. 457; also "J. L. Clarke on the Anatomy of the Spinal Cord," Beale's Archives, 1858, Pt. III. p. 207.

† Schilling maintains that "fibres from the posterior roots never enter the anterior cornu." This is entirely opposed to the observations of Stilling and Clarke, as well as my own.

The connection of the posterior roots with the cells of the posterior cornu has never been determined so satisfactorily; and, as considerable difference of opinion exists among authors, I shall compare somewhat at length the principal views which have been maintained.

R. Wagner* divides the posterior roots into three classes, of which the first pass directly upwards to the brain, without entering the gray substance; the second enter the gray substance and unite with nerve-cells, either collected in groups or strewn singly through the posterior cornua; the third class of fibres, very considerable in number, do not contribute to sensation, but pass to the large cells in the anterior cornua from which the anterior roots arise. Schröder van der Kolk agrees with Wagner, that the true *sensitive* fibres ascend directly to the brain without entering the gray substance, the only fibres from the posterior roots which enter the gray substance being, according to him, the *reflex*, i. e. transverse, and these he infers may enter cells.† Stilling‡ states that he has "never yet succeeded in observing the direct communication of a primitive nerve-fibre of the posterior roots with a nerve-cell of the gray substance, although he maintains this relation between them." Clarke§ describes and figures (Pl. XIX. Fig. 1) cells of the gelatinous substance as continuous by their processes with the posterior roots; of the cells constituting the *posterior vesicular columns* he says, "When the posterior roots of the nerves are traced inwards, they are found to be most intimately connected with all parts of the *posterior vesicular columns*." (p. 445.) He also states, that "the processes of these cells (of the posterior vesicular columns) are prolonged in every direction, — transversely they are continuous on the one hand with the posterior roots of the nerves, and on the other hand with the posterior commissure."‖ These statements are illustrated in the Philosophical Transactions for 1859 by very accurate figures, Pl. XIX. being certainly the *only* correct delineation of the posterior cornu hitherto published. Figs. 6 and 7 of my own drawings illustrate the connections which are seen to exist between cells of the posterior cornu and the nerve roots. In the longitudinal section (Fig. 6), fibres from the cells will be seen to be continuous with the transverse bundles *b*, *b*, and the ascending bundles *c*, *c*, which are direct continuations of the posterior roots, being shown in the figure soon after their passage through the *substantia gelatinosa*, the line *d d* marking very nearly the boundary between the more opaque portion of the *caput* and the *cervix cornu.* Fig. 7, from a transverse section, represents the manner in which the cells are connected with the

* Neurolog. Untersuch., (Göttingen, 1854,) p. 66.

† *Op. cit.*, p. 47.

‡ Neue Untersuch., p. 929.

§ Philos. Trans., Pt. I., 1859.

‖ J. L. Clarke on the Anatomy of the Spinal Cord, Beale's Archives, No. III.

posterior roots, and with various bundles of fibres traversing the posterior cornu in all directions. In transverse sections made from the lumbar region, one or more large cells are usually met with just at the junction between *cervix* and *caput*, on the inner margin of the cornu, these cells being connected with the posterior roots in a manner entirely at variance with all our present ideas of nervous conduction. One such cell is drawn (Fig. 7, *B*), and it will be noticed that, instead of being connected with a *single* bundle, it is connected by its processes with no less than *four distinct bundles belonging to the posterior roots.** It is, moreover, highly probable that these four bundles proceed from different, if not distinct, parts of the body, so that *possibly we have here sensations from four more or less distinct parts of the body, centralized in one nerve-cell;* how they are separately conveyed to the sensorium as distinct sensations I have been able to form no idea, but the fact is extremely interesting. I have been able to satisfy myself from the examination of many specimens that this is by no means an exceptional case, and I think hardly any preparation will be found, at least from the lumbar enlargement, which will not show one or more such cells in this part of the cornu. I have since noticed that Clarke has figured one such cell, occurring in the same part of the cornu, in the cervical enlargement.† In the anterior cornu the same thing is sometimes met with; I have several times seen cells connected with two or more fibres going to different bundles of anterior roots, as has already been figured by Clarke‡ and Schröder van der Kolk.§ It is not easy to observe this in the cords of the larger animals, since the cells from which the anterior roots arise are mostly situated at some distance from the entrance of the roots; but in the smaller animals, as the cat and rabbit, and in the human cord, such cells may often be found; on the contrary, posterior cells of this kind are most easily seen in large cords. The only class of cells belonging to the posterior cornu between which and the posterior roots I have failed to trace any connection, are most of the very small cells met with in every part of the cornu, the nature of which, as stated above, I consider very doubtful. Many of the cells situated in the set of fibres surrounding the posterior cornu may be seen sending out their processes into the posterior roots; this is especially apparent in longitudinal sections, where they are situated one above another at pretty regular intervals, obviously connected with the posterior roots.

* The cells drawn in Fig. 7 are the posterior cells of the *posterior vesicular column.*

† Philos. Trans. 1859, Pl. XIX. Fig. 1.

‡ Philos. Trans. 1859, Fig. 12.

§ *Op. cit.*, Fig. 6.

From what has gone before, it appears that there are probably, as regards origin, the three following classes of nerve-roots, viz.: —

1st. { (*a*) Anterior roots which arise from or terminate in anterior cells.
(*b*) Posterior roots " " " " " posterior cells.

2d. Anterior and posterior roots which meet in cells in the central part of the cord.

3d. " " " " which are directly continuous, i. e. unconnected with any cells in the cord.

The first class consists of nerve-roots which are united, if at all, through the medium of deeper lying cell-groups, those of the last two classes being more directly continuous. I am, however, very far from intending to imply any supposed difference of function between these classes, for I am very strongly convinced that the *function* of cell and fibre is everywhere the same; and one of the principal objects I have had in view in the above classification has been to show how closely anterior and posterior roots are connected, and how nearly they come to having a common origin.

(*c.*) *The Connection of the Cells with the Longitudinal White Fibres.*—This connection can be very plainly made out in the anterior and antero-lateral columns, between cells situated just at the outer margin of the anterior cornu and the adjacent longitudinal white fibres, these latter being seen to be direct continuations of cell processes, passing in a transverse direction a greater or less distance before turning upwards. This course is represented in Fig. 5, *a*, *a*; the bundles formed by these ascending fibres are seen at *a′*. Schröder van der Kolk gives an accurate figure of this derivation of the white fibres (*loc. cit.*, Fig. 5), agreeing with Bidder that *all* the longitudinal fibres of the anterior and lateral columns arise from cells. Stilling, on the other hand, maintains "that the whole white substance of the spinal cord (like the separate columns) has a double origin, peripheral and central."

The whole subject of the constitution and origin of the white columns needs careful investigation, more so, perhaps, than any other part of the cord; my own observations have led me to the following views, which are, however, merely an outline of the subject. The anterior and lateral columns, apart from the anterior roots, are only *partially* derived from the cells of the anterior and posterior cornua, *some* of the white longitudinal fibres seeming to be direct continuations of the posterior roots, after these have passed through the gray substance; the posterior white columns are composed almost exclusively of the posterior roots, a few fibres appearing to be derived from cell processes coming from the large cells, situated on the margin of the posterior cornu; what course these latter fibres take after leaving the gray substance I have been unable to determine definitely.

II. *The Course of the Nerve-Roots.*

The course taken by the nerve-roots, both anterior and posterior, as seen in transverse sections, has been described with so much exactness by Clarke, that I shall draw almost all the details of my description from longitudinal sections, which have been less carefully studied.

The Posterior Roots.—These are attached *solely to the posterior columns*, of which they form by far the greater part; this view is in accordance with Clarke (Philos. Trans. 1851), and still maintained in his more recent papers. Stilling, however, regards the lateral columns as receiving some fibres directly from the posterior roots; but after careful examination I am convinced that the fibres Stilling figures in this situation (which I have had no difficulty at all in seeing very distinctly in preparations made by Clarke's method) do not belong to the posterior roots, which from their direction they obviously could not join, but are probably radiating fibres, about to turn upwards into the longitudinal columns; this is especially evident in the cord of the cat, where the sulcus is quite deep, and the bundles constituting the posterior roots are kept very distinct.

Fig. 8, which is an accurate drawing, made by means of the camera lucida, from a longitudinal section across the lumbar enlargement of the calf, will serve to show that the course of the posterior roots within the posterior white columns is exceedingly intricate. The fibres may, however, be seen to take four principal courses:—1st. Fibres which ascend obliquely upwards and inwards, penetrating sooner or later into the gray substance, according to the degree of their obliquity. (Fig. 8, *b*, *b.*) 2d. Fibres which may be slightly oblique at starting, but soon assume a directly transverse course, sometimes varying this by slightly ascending or descending; these fibres are mostly of the finest sort. (Fig. 8, *e*, *e.*) 3d. Fibres which enter the posterior column at various angles, but very soon bend round, often at quite a sharp angle, descending in a course more or less oblique. (Fig. 8, *c*, *c.*) 4th. Fibres which are looped or recurrent, seeming to unite both ascending and descending fibres. (Fig. 8, *d*, *d.*) Besides these four classes, the first three of which have been already noticed by Stilling, every variety of intermediate course will be found, the bundles of fibres being braided together in the most complex manner.

The fibres of the first class, or *oblique ascending* fibres, seem to be the most numerous, comprising fully one half of the posterior nerve-roots; they usually enter the posterior columns at an angle not far from 45°, pursuing the same course for a considerable distance; after penetrating the outer two thirds of the column, they often vary

more or less from this angle, sometimes curving round and taking a direction nearly transverse before entering the cornu, or, as is sometimes the case, one or two of the fibres enter some one of the cells situated just at the border of the gelatinous substance; usually, however, these bundles curve still more upwards, assuming finally a direction nearly longitudinal, in which case it becomes extremely difficult to follow them; for although they can often be traced a very considerable distance, and are occasionally seen to enter the gray substance, more frequently they are hidden by bundles which cross them, or terminate suddenly, being cut across by the section. It is therefore quite impossible to say with absolute certainty whether *all* these fibres enter the gray substance, or whether part of them are continued upwards to the brain. Many of them may be traced directly into the gray substance, and most of the others converge very gradually, but steadily, towards the same destination, so that, if any fibres continue their longitudinal course upwards to the brain, the number must be very small, by no means sufficient to conduct all the sensitive impressions, as Schröder van der Kolk has imagined. When we examine the *descending oblique* bundles, we shall see that some of these pursue an equally longitudinal course; but surely every one would admit that these must enter the gray substance, rather than be prolonged down into the *filum terminale.* It is therefore highly probable on theoretical ground, and our observations point strongly in the same direction, that *all* the ascending fibres enter the gray substance; still it is to be remembered that this is not yet *anatomically* proved, if indeed it ever can be. This conclusion is also fully in accordance with the physiological experiments of Brown-Sequard* and Schiff,† proving that all the sensitive fibres enter the gray substance within a distance of a few centimeters at most from their starting-point. Intermixed with the oblique ascending fibres may be noticed a variety of bundles, which, instead of pursuing an oblique course, become nearly longitudinal very soon after their entrance into the column, often following a wavy course, interlacing in a very curious manner with the transverse and oblique bundles (Fig. 8, *f*, *f*), doubtless serving to convey sensitive impressions to portions of the cord situated at quite a distance above the entrance of the root. These bundles may *sometimes* be followed through a gradually converging course into the cornu.

The fibres of the second class, or *transverse* fibres (Fig. 8, *e*, *e*), vary but little from this direction; they usually enter the cord as part of some other bundle, depending upon it somewhat for their after course, ascending or descending slightly according to their derivation from ascending or descending bundles. They are sometimes connected

* Comptes Rendus de la Soc. de Biologie, 1855. Journal de la Physiologie, Jan. 1858.

† Lehrbuch d. Physiologie, 1858, p. 250.

with cells just at the margin of the cornu, but usually enter deeply into the gray substance, continuing, as will be shown later, in a more or less transverse course. These fibres appear to be much finer than those of the other classes, and it is therefore difficult to estimate their numerical proportion; they are certainly less numerous than those of the first class.

The fibres of the third class, or *oblique descending*, are quite numerous (Fig. 8, *c*, *c*); they sometimes enter the cord in company with an ascending bundle, following this for a short distance and then bending round, often at a very sharp angle, pursuing an oblique descending course, the exact counterpart of that followed by the oblique ascending bundles. Sometimes the bundle will be seen to divide (Fig. 8, *c′*), part of the fibres immediately entering the gray substance, while a portion plunge farther downwards, thus entering the gray substance at different depths below the starting-point. That all these fibres finally enter the gray substance hardly admits of doubt, since no one could suppose that fibres were indefinitely prolonged downwards, whatever theory might be assumed regarding the ascending bundles. This is fully in accordance with the experiments of Brown-Sequard,* showing that all the descending fibres enter the gray substance within a distance of about five centimeters from their starting-point. I cannot, however, agree with Brown-Sequard that these are more numerous than the ascending fibres; it is sometimes difficult to say with certainty whether a bundle ascends or descends, but notwithstanding this uncertainty the ascending fibres seem considerably more numerous.†

The fourth class, or *looped recurrent* fibres (Fig. 8, *d*, *d*), seem to unite both ascending and descending bundles. Their course is usually as follows: starting from the ascending end of the bundle, the fibres penetrate the posterior column as far as the margin of the gray substance; here the bundle often divides, part of its fibres passing upwards, whilst a part penetrate the gray substance, pursuing a slightly oblique, ascending course; they frequently proceed upwards for a considerable distance, finally looping round and re-entering the white column, joining some bundle with which they pass out, either the root immediately above their entrance, or, as is often the case, one higher up. In tracing the course of such a looped bundle, it is impossible to say

* Comptes Rendus de la Soc. de Biologie, 1855, p. 79.

† Within the gray substance *most* of the fibres from the posterior roots, after traversing the *substantia gelatinosa*, pursue a descending longitudinal course for some distance, as will be seen when we consider the central course of the nerve-roots, and this may *possibly* be the explanation of Brown-Sequard's experiments and deductions.

whether it is ascending or descending, origin and exit being obviously merely descriptive terms when applied to these fibres. These recurrent bundles have already been mentioned by Clarke,* in describing the oblique fibres. "Many of them," he says, "both singly and in small bundles, may be observed to form loops by returning to the white columns." Clarke also mentions, what I have often observed, that a few of the fibres from the oblique bundles "proceed near the surface both upwards and downwards, and pass out again with the roots above and below them." These are also plainly seen in transverse or obliquely transverse sections. Stilling denies the existence of looped returning fibres, assuming that Clarke had been deceived by confounding ascending with descending fibres (*loc. cit.*, p. 1186); this, however, is far from being the case. I have been able repeatedly to verify Clarke's statement, and have frequently been able to trace such bundles or fibres from root to root, both in longitudinal and transverse sections. These looped fibres appear to occur frequently in the nervous system of some of the lower animals, especially in *Lumbricus terrestris*, as described by Clarke † and Faivre, ‡ in the abdominal cord of which they are very numerous.

The above description of the fibres derived from the posterior roots agrees mainly with Stilling's, differing, however, in regard to the fourth class. My reason for not following the classification of Clarke has been, that I felt obliged to arrange the fibres entirely with reference to their course within the posterior white columns, from the conviction that neither of the three central courses according to which Clarke has mainly classified them originated from any one particular set of fibres belonging to the posterior columns.

The Central Course of the Nerve-Roots.—In longitudinal sections made parallel to the median fissure, the *substantia gelatinosa* is seen to be traversed by numerous bundles of fine fibres, running transversely through it, nearly parallel to each other.

The three different classes of fibres mentioned above—viz. ascending, descending, and transverse—pass indiscriminately into these *central* transverse bundles (Fig. 8), which are, as Clarke has already noticed, often somewhat fusiform in appearance. I have uniformly found that these bundles pursue the same central course in the lumbar enlargement which he has described with so much accuracy in the cervical enlargement of the cat; § after traversing the *substantia gelatinosa* in a direction nearly transverse, they curve round, some upwards, some downwards, running a considerable distance as longitudinal fibres, forming by their union those bundles which are seen

* Philos. Trans. 1853, p. 350.

† Proceedings of the Royal Society, Jan. 27, 1857.

‡ Histologie Comparée du Syst. Nerv. Paris, 1857.

§ Philos. Trans. 1853.

cut across in transverse sections, especially well marked near the junction of *cervix* and *caput cornu.* These longitudinal bundles are often of quite considerable size (Fig. 8, *h*, *h*). Clarke states that he has "not seen them distinctly below the cervical enlargement"; they are certainly more strongly marked, in the cat at least, in the cervical region, where they may be seen with very great distinctness, but I have had no difficulty in making them out very clearly in all my preparations from the lumbar enlargement of the calf. Clarke has described these bundles as "running down the cord," and this is usually the case, though occasional variations will be met with, bundles sometimes running upwards (Fig. 8); the great majority of fibres, however, undoubtedly run downwards.

These bundles of longitudinal fibres, which I propose to call *longitudinal columns of the cornua*, send out fibres anteriorly in all directions, many of them becoming connected with large cells which are found grouped along the whole length of these columns, belonging to Clarke's *columnæ vesiculares posteriores.* Fig. 6 represents the relation in which the cells stand to the longitudinal columns (*a*, *a*, *a*); they are also seen on a smaller scale in Fig. 8. The fibres composing these columns do not seem to follow a longitudinal course for any considerable distance, but usually soon pass onwards towards the anterior cornu. Many of the fibres pass obliquely to the commissures, both anterior and posterior; some pass out into the lateral white columns, while others pass forwards, becoming connected with cells, or else directly into the anterior roots, with which they are often continuous. Others assume every variety of upward or downward curve before reaching their final destination, a longitudinal section through the anterior cornu often presenting an inextricable web consisting mostly of cut-off fibres (Fig. 8).

A part of the transverse bundles which traverse the *substantia gelatinosa* do not seem to be connected at all with the *longitudinal columns of the cornua*, their fibres being plainly seen to cross these at right angles; they are mostly continued anteriorly for a very considerable distance, often becoming lost to view (or cut off), but may sometimes be seen to be directly continuous with the anterior roots.

It will be noticed in my description of the course taken by the fibres derived from the posterior roots, that I have given but little attention to that part of their course which is mainly traceable in transverse sections; this there was no need of doing, since Clarke has described it with *so much accuracy* in his latest paper (1859). I have myself verified most of the results at which he has arrived, and can add nothing.

Clarke states in his description of the longitudinal columns of the cornua, that a part of their fibres "form loops with each other within the gray substance, particu-

larly near its border; others extend directly into the anterior white columns, and bending round, both *upwards* and *downwards*, are seen sometimes to re-enter the gray substance and form with each other a series of loops, and sometimes to continue a longitudinal course within the anterior white columns, amongst the fibres of which they become lost. Whether the latter also ultimately form broader loops with corresponding fibres from the gray substance, it is impossible to ascertain. But even if those which *ascend* in the anterior columns are continued upwards to the brain, one can scarcely avoid inferring that those which *descend* re-enter the gray substance, either to form loops or to become continuous with the fibres of the anterior roots, since the whole of the latter, as we shall presently see, proceed directly from the gray substance."* This formation of loops near the border of the anterior cornu I have often noticed, and while I have no doubt that some of these loops found in the anterior columns are derived from the posterior roots, as stated by Clarke, I am convinced that a large portion of the looped fibres which are found in great abundance in the inner portion of the anterior white columns have a different origin, viz. from the cells of the anterior cornua, to which I have in some cases succeeded in tracing one or both ends of such fibres.†

The Anterior Columns and Roots.—The anterior white columns contain the following elements:—(1.) The anterior roots which traverse them in a slightly curved ascending course; and (2.) Fibres which vary from longitudinal to every variety of curved course, often forming loops which may be traced a greater or less distance through the column. These loops are formed in the following manner: bundles of fibres, some of which arise from cells near the margin of the anterior cornu (Fig. 8, *l*, *l*), may be traced in a longitudinal section, descending obliquely until they emerge from the gray substance into the anterior white column; here they continue the same general direction, finally curving round (as seen at *k*, *k*) and re-entering the gray substance; in my description I have traced this bundle downwards,—it is obviously impossible to say whether the fibres ascend or descend.

Fibres belonging to these bundles may sometimes be seen to join cells at both ends

* Philos. Trans. 1853, p. 349.

† Stilling entirely denies the existence of looped fibres anywhere, with the singular criticism, that "Clarke would allow that he had not followed the fibres in question continuously from the nerve-root on, through white and gray substance, into the white columns, and from these back again into the gray substance." (*Loc. cit.*, p. 1186.) This is the more extraordinary, since Clarke not only states that these fibres are *seen* to form such loops, but also figures them. (Philos. Trans. 1853.) It is by no means a very difficult thing to follow fibres quite across the cord in the smaller animals, such as the cat, from which Clarke's figure is drawn.

of the loop, thus standing probably in mediate connection with the anterior roots. Occasionally these fibres accompany the anterior roots for some distance, in which case they appear to share the origin of the anterior roots, either arising from cells or being direct continuations of the posterior roots, bending round subsequently, and pursuing either an ascending or descending course, finally curving round to re-enter the gray substance. A few of the curving fibres found in the anterior columns pass out a short distance with some bundle of anterior roots, leaving this soon, and curving upwards or downwards to join some other bundle of roots, either above or below, with which they pass out from the cord.

In concluding this paper, I cannot but feel fully aware of its extreme incompleteness; it expresses, however, the constant work of a year, during which time I have had occasion continually to feel grateful for aid and encouragement from kind friends, in which connection I cannot fail to mention the constant interest and kindness of Dr. O. W. Holmes, and my great indebtedness for many useful suggestions to Professor Jeffries Wyman, without whose aid I should hardly have begun this work, and certainly should not have carried it through.

The accompanying figures have all been drawn by myself, by means of the camera lucida; and although much interesting detail is necessarily omitted, I have endeavored to make them faithful representations of the most important facts, my constant effort having been to give too little detail rather than too much. I have etched them on copper myself, believing that microscopic drawings are too apt to lose much of their truth even in the hands of the most careful artist, and that a faithful, though somewhat rough transcript of the original drawing, made by the observer himself, must be of greater value than a more highly finished copy.

Conclusions.

1. That true nerve-cells exist only in the gray substance, these cells being connected by their processes in more or less definite groups; but not probably, as some authors maintain, so as to form an uninterrupted chain from brain to *filum terminale.*

2. That the anterior roots arise partly from nerve-cells, another portion being directly continuous with the posterior roots. A part of the posterior roots also enter cells.

3. The roots may therefore be divided into three classes; — such a division does not, however, imply any functional difference.

(1.) Anterior and posterior roots which arise from or terminate in anterior or posterior cells.

(2.) Anterior and posterior roots which meet in cells near the central part of the gray substance.

(3.) Anterior and posterior roots which are directly continuous.

4. That bundles of anterior roots are connected with those above and below, by looped fibres proceeding from cells which some of the roots enter; these fibres leaving the gray substance, and passing sometimes upwards, sometimes downwards through the anterior columns, finally curving inwards to join some other bundle of anterior roots with which they pass into the gray substance.

5. That thus fibres from nerve-cells after passing upwards through the longitudinal white columns, do not *all* continue onwards to the brain, but most of them re-enter the gray substance at a greater or less distance from the point of exit, sometimes probably becoming again connected with cells, and again emerging from these as longitudinal fibres.

6. That the processes from a single nerve-cell, whether in the anterior or posterior cornu, do not necessarily *all* pass into the *same* bundle of roots, but often pass into three or four different bundles; a cell process also sometimes sending branches into different bundles. Thus we may have sensitive impressions from different parts of the surface conveyed to one cell, and motor impulses distributed from one cell to different points.

7. That all the anterior and probably all the posterior roots enter the gray substance, though the posterior roots often pass into the cornu at a considerable distance from their first entrance into the cord.

8. That most of the fibres from the posterior roots, after traversing the posterior columns, are collected into transverse bundles, traversing the *substantia gelatinosa* in a slightly ascending course; after passing through which they curve downwards (*sometimes* upwards), forming, by the longitudinal course which they then maintain for some distance, a very interesting series of longitudinal bundles, which I have called *longitudinal columns of the cornua*, standing in very close relation to the *posterior vesicular columns* of Clarke, with the cell processes of which many of their fibres are continuous.

9. That some of the bundles which traverse the *substantia gelatinosa* do not pass into the *longitudinal columns of the cornua*, but proceed directly across the gray substance, becoming continuous with the anterior roots.

10. That the posterior white columns are composed almost entirely of the posterior roots, which merely traverse them before entering the gray substance. They appear, however, to receive a few fibres from cells situated on the extreme margin of the posterior cornua, and some more or less longitudinal fibres from the looped recurrent bundles.

11. That the posterior roots are connected by curved fibres or bundles of fibres, proceeding from one root and curving round after penetrating the gray substance, becoming connected with some other root above or below. The same is seen in transverse sections with regard to roots situated side by side, both anterior and posterior, the looping fibres sometimes proceeding directly from root to root, and sometimes passing through cells.

From which it results that the same fibre must in different parts of its course conduct both centrifugally and centripetally.

12. That, besides the looped recurrent fibres, the three principal courses taken by the posterior roots before entering the gray substance are with reference to a longitudinal plane, ascending oblique, descending oblique and transverse.

The method of preparation usually employed was a modification of Gerlach's and Clarke's, although many others were employed, according to the object in view. The following method gave the best results from which to make drawings. Thin sections from the cord, hardened in alcohol, were washed a few minutes in pure water, and then immersed in glycerine, to which Gerlach's solution of carmine,* previously filtered, had been added; in this the sections were allowed to remain four to eight hours, according to the tint desired (a light tint interfering least with the details and sharpness of outline). I have been able to obtain more delicately colored specimens and more clearly defined structure by the use of glycerine than by any other method. The sections are then washed first in pure water, afterwards with strong alcohol, in which they are allowed to remain about an hour, and are now ready for preparation with turpentine, according to Clarke's method; they may be put up in Canada balsam, or, as I have found very advantageous, in thick, colorless copal-varnish, which often preserves minute details better than balsam. Although Stilling and others have found much fault with Clarke's method of preparation, on account of the too great transparency it sometimes gives, I am convinced that, with practice and some slight modifications, it is the only one suited to the minute study of the cord, other methods seeming to me, after thorough trial, quite unsatisfactory as compared with Clarke's. As a hardening material, I have often employed chromic acid with considerable advantage; but when coloring-matter is used, alcohol is most suitable, and is certainly much easier to succeed with.

* Gerlach, Mikroskopische Studien, Erlangen, 1858. Solution of carmine in water, to which a few drops of strong ammonia have been added.

Explanation of the Plates.

Fig. 1. Transverse section representing part of the anterior cornu, from the lumbar enlargement of the rabbit. *a*, *a*, *a′*, bundles of fibres belonging to the anterior roots; in the bundle marked *a′* two cell processes can be traced to the outer boundary of the cord; *b*, *b*, outer boundary of the white substance; *c*, *c*, boundary of gray substance; *d*, *d*, cell connectives of the short, thick variety; *e*, a longer cell connective. Drawn by the camera lucida, with one of Nachet's microscopes, from a preparation magnified 160 diameters; the scale is in hundredths of a millimetre.

Fig. 2. Group of cells from the anterior cornu of the sheep, connected with the radiating bundles from which the longitudinal fibres of the white substance are derived. *a*, *a*, *a*, radiating bundles; *B*, a large cell, sending its processes, *b*, *b*, *b*, into four different bundles; *c*, a process passing forward towards the anterior roots; *d*, *d*, long cell connectives. Figs. 2 to 7, inclusive, were drawn by the camera lucida, with eye-piece No. 1, objective $\frac{4}{10}$ of one of Smith and Beck's first-class instruments, giving a power of 120 diameters; the scales affixed express thousandths of an inch. *This and the following figures are all from the lumbar enlargement.*

Fig. 3. Group of cells from the anterior cornu of the sheep, connected with the anterior roots at *A*; *B*, fibres radiating to the side of the cornu; *C*, fibres passing to the interior of the cornu. This figure represents a somewhat deeply lying group of cells as seen in a transverse section.

Fig. 4. Group of cells connected with the anterior roots, as seen in a transverse section, from the anterior cornu of the sheep. *A*, entrance of the anterior roots into the cornu; *b*, *b*, *b*, *b*, cells connected by long, slender processes with the anterior roots; *c*, *c*, boundary of the cornu. In this figure almost every variety of cell connection may be seen, with bundles of fibres crossing in every direction.

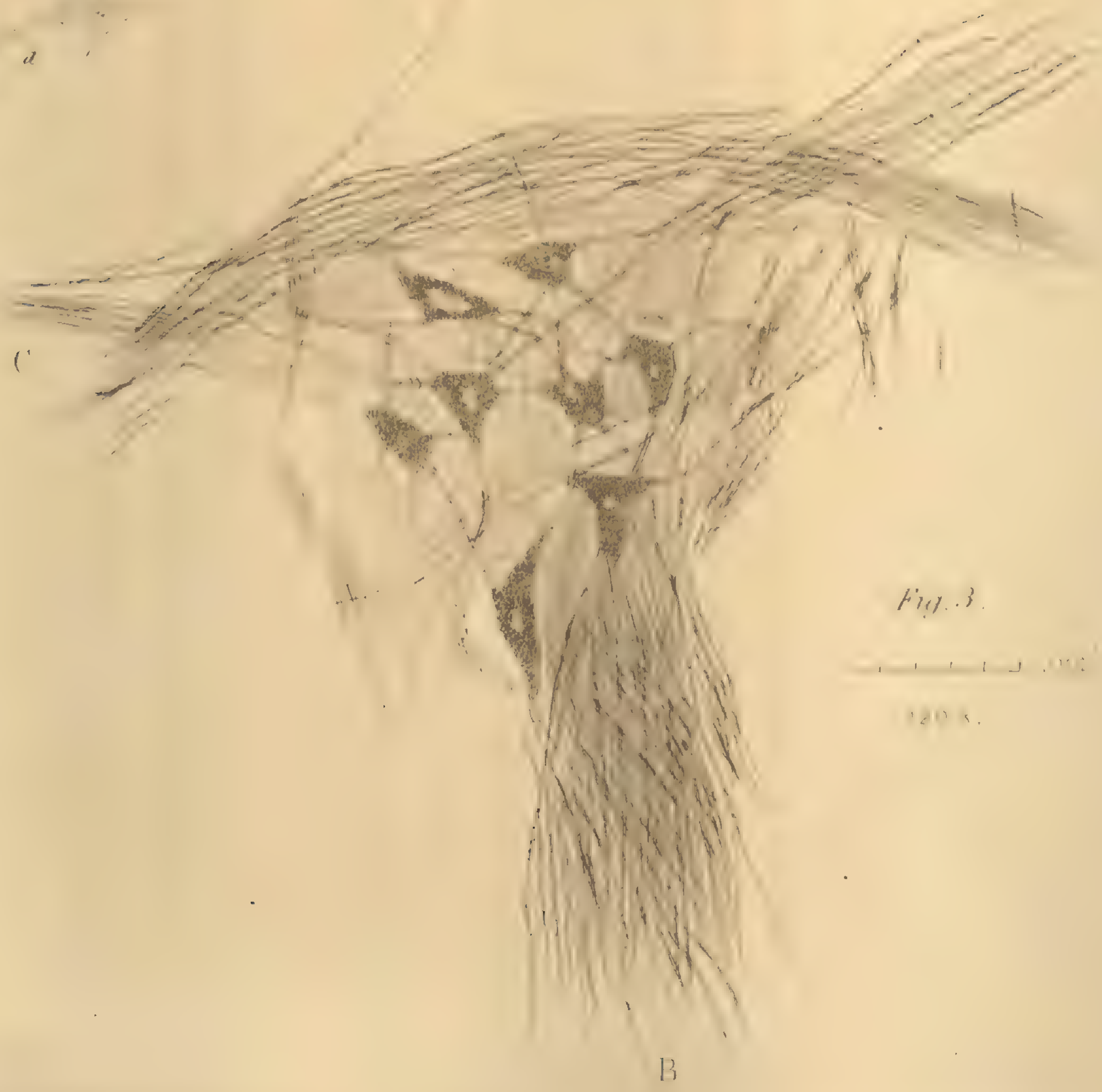
Fig. 5. Group of cells connected with the anterior roots, from a longitudinal section through the anterior cornu of the sheep. *A*, white substance; *B*, gray substance; *a*, *a*, cell processes passing upwards to form the ascending fibres of the white substance; *a′*, *a′*, bundles of ascending fibres; *b*, *b*, cell processes passing into the anterior roots; *b′*, *b′*, anterior root bundles; *c*, *c*, descending fibres and bundles (*c′*). Different forms of cell anastomosis may also be observed in this figure.

Fig. 6. Longitudinal section through the posterior cornu of the calf, drawn just inside the gelatinous substance, on a plane with the entrance of the posterior roots. *a*, *a*, *a*, ascending bundles of fibres, *longitudinal columns of the cornua*, connected on the one side with the posterior roots, and on the other with cells which belong to the *pos-*

Fig. 1

Fig. 2.

Fig. 3.



Dean ad nat. del. et sc.

Fig. 4.

A.

120 ×

.001"

Fig. 5.

B.

120 ×

.001"

J. Dean ad nat. del. et sc.

Fig. 6.

Fig. 7.

J. Dean, ad nat. del. et sc.

Fig. 3.

J.Dean ad nat.del.et sc.

terior vesicular columns; *b*, *b*, transverse bundles of fibres; *c*, *c*, ascending oblique bundles, seen in many places passing into the longitudinal bundles; *d*, *d*, line marking the boundary between *cervix* and *caput cornu*, the figure comprising chiefly the *cervix*.

Fig 7. Transverse section through part of the posterior cornu of the calf, showing the side of the cornu next the median fissure with the entrance of the posterior roots. The figure gives part of the *caput cornu* immediately adjoining the gelatinous substance, with most of the *cervix*; a line drawn parallel to the bottom of the paper, through *B*, would about mark the junction between *cervix* and *caput*; *a*, *a*, boundary of the cornu; *a'*, *a'*, bundles formed by the posterior roots; *B*, a large cell, sending four of its processes into four different bundles of posterior roots.

Fig. 8. Longitudinal section completely through the lumbar region of the cord, from the calf, the section which is parallel with the median fissure comprising both anterior and posterior columns and roots. *A*, anterior white columns; *P*, posterior white columns; the intermediate space representing the gray substance; *a*, *a*, *a*, anterior roots; *k*, *k*, looping fibres connecting two different bundles of anterior roots; *l*, *l*, descending bundles within the gray substance, which seem to be the origin of the fibres, *k*, *k*; *m*, *m*, descending fibres; *n*, *n*, ascending fibres; *c*, *c*, descending oblique fibres in the posterior columns; *b*, *b*, ascending oblique fibres; *e*, *e*, transverse fibres; *c'*, descending bundle, part of which enters the gray substance, another portion continuing a descending course within the white column; *d*, *d*, looped fibres, forming loops within the gray substance (several examples of this are seen along the boundary between gray and white substances); *f*, *f*, bundles which continue in a longitudinal course for a considerable distance; *p*, *p*, bundles of posterior roots outside the cord; *g*, *g*, transverse bundles of fibres traversing the *substantia gelatinosa*; *h*, *h*, *longitudinal columns of the cornua* formed from the transverse bundles *g*, *g*; *s*, bundles which are cut across by the plane of section (many such will be seen in various parts of the gray substance); the cells are merely sketched, the magnifying power being too low to give any detail of their connections with the fibres. This figure was drawn by the camera lucida with eye-piece No. 1, objective $1\frac{1}{2}$ inch, giving a power of about thirty diameters. The scale is in hundredths of an inch.

XII.

On some of the Relations of Salts of Zinc and Alumina to Soda and Potassa.

By E. N. HORSFORD.

(*Communicated September* 11, 1860.)

On the addition of caustic soda to a solution of neutral sulphate of zinc there follows a precipitate which disappears in an excess of the soda. A solution of neutral sulphate of alumina exhibits under like conditions the same phenomena, and both salts comport themselves with potassa as they do with soda. Alumina is thrown down from its solutions in potassa and soda by chloride of ammonium and by mineral acids, while oxide of zinc is not in like manner precipitated from its solution in these alkalies.

The following results present some of the quantitative relations of these agents to each other.

Experiments with Sulphate of Zinc.

Strength of Solutions.

1 cubic centimetre of the solution of sulphate of zinc contains			0.0257	gram. oxide of zinc,
		equal to	0.05108	gram. anhydrous sulphate of zinc.
1	" "	soda solution contains	0.04313	gram. soda.
1	" "	potassa solution contains	0.0230	gram. potassa.

Experiments with Soda.

		Required to complete Precipitation.	Required to precipitate and re-dissolve.
	$ZnO . SO_3$.	NaO.	NaO.
	5 c. c.	2.3 c. c.	7.6 c. c.
	"	"	"
	"	"	"
	"	"	"
	"	"	"
	"	"	"
Average,	5 c. c.	2.3 c. c.	7.6 c. c.

5 c. c. of solution of $ZnO . SO_3$	contain	0.1285 gram.	ZnO.
2.3 " " NaO	"	0.0983 gram.	NaO.

By deducting from 7.6 c. c. the amount 2.3 c. c. required for precipitation, we have the amount required for resolution.

5.3 c. c. of solution of NaO contain 0.2286 gram. NaO.

Now 0.0983 gram. NaO will neutralize 0.1268 gram. SO_3; for

$$31 : 40 = 0.0983 : 0.1268.$$

But the sulphuric acid in 5 c. c. of sulphate of zinc is 0.1269 gram.; for

$$80.5 : 40 : 5 \times 0.05108 = 0.2554 : 0.1269.$$

There is, therefore, required to precipitate oxide of zinc precisely one atom of soda to one atom of sulphate of zinc.

Theory requires of the sulphuric acid to be neutralized . . .	= 49.67	per cent.
Experiment gives for the equivalent of sulphuric acid to the soda employed	49.61	"

The reaction is

$$ZnO . SO_3 + NaO = ZnO + NaO . SO_3.$$

In order to re-dissolve the oxide of zinc 0.2286 gram. of NaO is required, a quantity 2.3 times as great as was required to precipitate it. To ascertain the influence of the quantity of water on the reaction, experiments were made with soda solution, of which 1 c. c. contained 0.1889 gram. of soda.

10 c. c. of the sulphate of zinc solution required, to precipitate and re-dissolve, 2.9 c. c. of soda solution. This is equal to 2.78 equivalents, of which one being employed to precipitate, there remain for resolution 1.78 equivalents. It is obvious, therefore, that the solution of the oxide of zinc is influenced by the quantity of water present. The larger the proportion of water — within the limits of these experiments — the less perfect was the solution of the precipitated oxide.

Experiments with Potassa.

5 c. c. of sulphate of zinc solution required to complete precipitation, as the result of many coincident determinations, 5.1 c. c. of the potassa solution.

5 c. c. of solution of $ZnO . SO_3$	contain	0.1285	gram.	ZnO
	and	0.1269	"	SO_3.
5.1 " " KO	contain	0.1173	"	KO.

Now 0.1269 gram. of sulphuric acid requires for neutralization 0.1491 gram. of

potassa, — a quantity to which 0.1173 gram. sustains the relation of 3 : 3.81, or nearly of 3 : 4. It is obvious, therefore, that the chief part of the precipitate was the well-known compound 4 $ZnO . SO_3$.

Resolution was attended with much greater difficulty. The results were so variable, that no confidence could be placed in them. The influence of water was observed here as in the experiments with soda. The potassa was too dilute.

A more concentrated solution, of which 1 c. c. contained 0.2590 gram. of potassa, gave the following result.

10 c. c. of solution of $ZnO . SO_3$ required 4 c. c. of solution of KO to precipitate and re-dissolve. Allowing, according to the preceding determination, .75 of an equivalent for the precipitation, there are required to re-dissolve 2.65 equivalents.

Bonnet dissolved two parts of hydrated oxide of zinc in five parts of potassa solution of 1.3 specific gravity. Such a solution contains about .25 part of KO. 5 c. c. would contain 1.25 grammes, which would give about two atoms of zinc dissolving in $1\frac{1}{4}$ of potassa; or the soluble compound would be 8 ZnO . 5 KO. The compound is probably that obtained by Fremy,* — two atoms of oxide of zinc to one of potassa. This compound, upon the slightest addition of water, resolved itself, according to Fremy, into anhydrous oxide of zinc and hydrated potassa. These facts sufficiently explain the difficulty of obtaining satisfactory results in the attempts to re-dissolve with a solution of the strength here employed.

Experiments with Sulphate of Alumina.

Common potassa alum, refined by repeated crystallizations, was dissolved in distilled water.

1 c. c.	of the	alum	solution	contained	0.0371	gram. of	crystallized potassa alum.
"	"	"	"	"	0.009386	"	SO_3, combined with alumina.
"	"	soda	"	"	0.0430	"	NaO.
"	"	potassa	"	"	0.0230	"	KO.
"	"	sulphuric acid	"	"	0.03264	"	SO_3.
"	"	chloride of ammonium	"	"	0.03305	"	NH_4Cl.

Experiments with Soda.

	Alum.	C. c. of Soda required to precipitate.	C. c. of Soda required to precipitate and re-dissolve.	C. c. of Sulphuric Acid required to re-precipitate.	C. c. of Chloride of Ammonium required to re-precipitate.
	10 c. c.	1.4	2.7	1.0	2.9
	"	1.4	2.7	1.0	2.9
	20 c. c.	2.8	5.4	2.0	5.8
	"	2.8	5.4	2.0	5.8
Average,	10 c. c.	1.4	2.7	1.0	2.9

* Compt. Rend., XV. p. 1106.

10 c. c. alum solution contain	0.3710	gram.	alum.
" " " "	0.09386	"	SO_3, combined with alumina.
1.4 c. c. soda solution "	0.0602	"	NaO.
" " will neutralize	0.07767	"	SO_3.
2.7 c. c. soda will contain	0.1161	"	NaO.
" " correspond with	0.1498	"	SO_3.

0.09386 gram. SO_3	= 25.30 per cent ;	3 atoms	= 25.30 per cent.
0.07767 " "	= 20.93 "	$2\frac{1}{2}$ "	= 21.07 "
0.1498 " "	= 40.37 "	5 "	= 42.15 "

According to these results, two and a half atoms are required completely to precipitate the alumina, and a little more than an equal quantity to re-dissolve the precipitate. Expressing these relations in formulæ we have, omitting the sulphate of potassa of the alum,

$$2\,[Al_2O_3 . 3\,SO_3] + 5\,NaO = \underline{2\,Al_2O_3 . SO_3} + 5\,[NaO . SO_3].$$

$$\underline{2\,Al_2O_3 . SO_3} + 5\,NaO = 2\,[Al_2O_3 . 2\,NaO] + NaO . SO_3.$$

The sulphuric acid of the precipitate may be more or less withdrawn by long continued washing, showing how feeble the affinity is, where the action of water in quantity is brought to bear on both the constituents of the precipitate.

The constitution of the soda and alumina compound in the resolution differs from that of the soluble compound prepared by fusing together alumina and carbonate of soda, by Schaffgotsch,* which had only one atom of soda to one of alumina.

If these two atoms of soda to each atom of alumina require, in order to the precipitation of the alumina, two atoms of sulphuric acid, we have,

$\frac{2}{5}$ of 0.1161 gram. NaO		= 0.04644 gram.	
0.4644 " NaO correspond with		0.059991 "	of SO_3.
1 c. c. of the sulphuric acid solution contained		0.03264 "	

a quantity but little more than one half that required to neutralize the SO_3. The formula will be therefore

$$Al_2O_3 . 2\,NaO + SO_3 = \underline{Al_2O_3 . NaO} + NaO . SO_3.$$

It is not to be denied that this result seems inconsistent with the solubility of the compound obtained by Schaffgotsch, unless it be admitted that the alumina which has been combined by heat with soda is modified in its properties.

The precipitation with chloride of ammonium required a little more than a full equivalent. $\frac{2}{5}$ of 0.1161 gram. NaO = 0.4644 gram., and require 0.8014 gram.

* Pogg. Ann., LIII. p. 117.

NH_4Cl. Experiment gave 0.9580 gram. NH_4Cl, a ratio of 5 : 6. These relations may be expressed by the formula

$$5\,(Al_2O_3 . 2\,NaO) + 12\,NH_4Cl = 5\,(Al_2O_3 . 2\,NH_3) + 10\,NaCl + 2\,NH_4Cl.$$

The occurrence of the surplus NH_4Cl suggested the following experiment. With a given alum solution in soda as above, three solutions of sal-ammoniac were taken, of relative strengths as 1 : 2 : 3.

10 c. c. of the soda solution of alumina required of	No. 1	for complete precipitation	0.3 c. c.
" " " " " "	No. 2	" "	1.0 "
" " " " " "	No. 3	" "	2.5 "

If we multiply the number of cubic centimetres of the strongest by three, and that of the medium by two, we have 0.9 : 2 : 2.5, showing that the more concentrated is much more efficient proportionally than is due to the excess of chloride of ammonium it contains. In other words, that in proportion as the quantity of water is increased, so is the efficiency of the reagents enfeebled.

Experiments with Potassa.

	Alum.	Potassa required to precipitate.	Potassa required to precipitate and re-dissolve.	Sulph. Acid required to re-precipitate.	Chloride of Ammonia required to re-precipitate.
	10 c. c.	3.2 c. c.	7.3 c. c.	1.5 c. c.	4.3 c. c.
	"	"	"	"	"
	"	"	"	"	"
Average,	10 c. c.	3.2 c. c.	7.3 c. c.	1.5 c. c.	4.3 c. c.

10 c. c. of the alum solution contain	0.3710	gram.	alum.
" " " "	0.09386	"	SO_3, combined with alumina.
3.2 c. c. of the potassa solution contain	0.07360	"	KO.
7.3 " " " "	0.16790	"	KO.
3.2 " " " will neutralize	0.06263	"	SO_3.
7.3 " " " "	0.1429	"	SO_3.

0.09386 gram. SO_3	= 25.30 per cent ;	3 atoms	= 25.30 per cent.
0.06263 " "	= 16.88 "	2 "	= 16.86 "
0.14290 " "	= 38.52 "	$4\frac{1}{2}$ "	= 37.95 "

According to these results, two atoms are required to precipitate, and a little more than two and a half to re-dissolve. Expressing these relations in formulæ, we have,

$$Al_2O_3 . 3\,SO_3 + 2\,KO = \underline{Al_2O_3 . SO_3} + 2\,[KO . SO_3].$$

$$2\,[\underline{Al_2O_3 . SO_3}] + 5\,KO = 2\,Al_2O_3 . 3\,KO + 2\,[KO . SO_3].$$

The precipitate is the same as that which, according to Berzelius, is thrown down

by ammonia, and identical in the relations of alumina to sulphuric acid with native *aluminite*. The compound formed in the resolution differs from the compound obtained by Unverdorben,* and in crystallized form by Fremy,† by saturating boiling potassa with alumina, in that it contains half an atom of potassa more. This is not more striking than the contrast displayed between the compound in the resolution of alumina in soda, and the body produced by Schaffgotsch by melting carbonate of soda and alumina together.

The sulphuric acid required to re-precipitate the alumina somewhat exceeded one equivalent.

$1\frac{1}{2}$ atoms KO $= \frac{3}{4}$ of 0.0736 gram. $=$	0.0552	gram.	KO.
0.0552 gram. KO correspond with	0.0469	"	SO_3.
1.5 c. c. of sulphuric acid solution contain	0.04896	"	SO_3.

The formula most nearly expressing the reaction would be,

$$2\,Al_2O_3 . 3\,KO + 3\,SO_3 = 2\,Al_2O_3 + 3\,[KO . SO_3].$$

It appears, therefore, that while all the alumina is thrown down by sulphuric acid from its soda solution with an equivalent of soda in combination not saturated, it is not entirely precipitated from its potassa solution by the same reagent till all the potassa has been withdrawn by the sulphuric acid, or till an equivalent of sulphuric acid for all the potassa has been added.

The chloride of ammonium required to re-precipitate the alumina from its solution in potassa is somewhat more than two equivalents of the chloride to one of the potassa in combination with the alumina.

$1\frac{1}{2}$ atoms of KO $=$ 0.0552 gram., which corresponds with	0.0626	gram.	NH_4Cl.
4.3 c. c. of chloride of ammonium solution contain	0.1421	"	NH_4Cl.

It is doubtless true with this, as with the corresponding soda result, that the quantity of chloride of ammonium required to produce precipitation, is influenced by the degree of dilution of the reagents.

The above result is most nearly expressed by the formula,

$$2\,[Al_2O_3 . 3\,KO] + 6\,NH_4Cl = 2\,[Al_2O_3 . 3\,NH_3] + 6\,KCl.$$

The compound most nearly allied to this is Rose's compound of chloride of aluminum and ammonia,

$$Al_2Cl_3, 3\,NH_3,$$

obtained by passing dry ammoniacal gas over chloride of aluminum.‡

* Pogg. Ann., VII. p. 323.

† Compt. Rend., XV. p. 1106.

‡ Pogg. Ann., XXIV. p. 228.

The foregoing results may be presented in the following formulæ.

Sulphate of Zinc and Soda.

1. $ZnO . SO_3 + NaO = \underline{ZnO} + NaO . SO_3.$

Sulphate of Zinc and Potassa.

2. $4\,[ZnO . SO_3] + 3\,KO = \underline{4\,ZnO . SO_3} + 3\,[KO . SO_3].$

Sulphate of Alumina and Soda to Precipitation and Resolution.

3. $2\,[Al_2O_3 . 3\,SO_3] + 5\,NaO = \underline{2\,Al_2O_3 . SO_3} + 5\,[NaO . SO_3].$

4. $\underline{2\,Al_2O_3 . SO_3} + 5\,NaO = 2\,[Al_2O_3 . 2\,NaO] + NaO . SO_3.$

Re-precipitated with Sulphuric Acid.

5. $Al_2O_3 . 2\,NaO + SO_3 = \underline{Al_2O_3 . NaO} + NaO . SO_3.$

Re-precipitated with Chloride of Ammonium.

6. $5\,[Al_2O_3 . 2\,NaO] + 12\,NH_4Cl = 5\,[\underline{Al_2O_3 . 2\,NH_3}] + 10\,NaCl + 2\,NH_4Cl,$

or, probably,

$$Al_2O_3 . 2\,NaO + 2\,NH_4Cl = \underline{Al_2O_3 . 2\,NH_3} + 2\,NaCl.$$

Sulphate of Alumina and Potassa to Precipitation and Resolution.

7. $Al_2O_3 . 3\,SO_3 + 2\,KO = \underline{Al_2O_3 . SO_3} + 2\,[KO . SO_5].$

8. $2\,\underline{[Al_2O_3 . SO_3]} + 5\,KO = 2\,Al_2O_3 . 3\,KO + 2\,[KO . SO_3].$

Re-precipitated with Sulphuric Acid.

9. $2\,Al_2O_3 . 3\,KO + 3\,SO_3 = \underline{2\,Al_2O_3} + 3\,[KO . SO_3].$

Re-precipitated with Chloride of Ammonium.

10. $2\,Al_2O_3 . 3\,KO + 6\,NH_4Cl = 2\,[Al_2O_3 . 3\,NH_3] + 6\,KCl.$

It is probable that in some of these reactions the salts, represented in the formulæ as in solution, are in part more or less firmly combined with the precipitates. It is unquestionable that water enters into the constitution of many of the precipitates. The formulæ give only the relations of the quantities to the facts of precipitation, resolution, and re-precipitation. They illustrate, also, incidentally, the influence of water on the efficiency of a reagent.

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XIII.

On the Measure of the Forces of Bodies moving with different Velocities.

BY DANIEL TREADWELL,

VICE-PRESIDENT OF THE ACADEMY, AND LATE RUMFORD PROFESSOR IN HARVARD UNIVERSITY.

[This paper was read to the Academy in March, 1854, as here printed, except a few sentences since added by way of illustration (as that from Brewster's "Life of Newton"), and some trifling verbal alterations.]

ALTHOUGH the great controversy on the measure of the forces of moving bodies, which divided the investigators of mechanical science during a part of the seventeenth and eighteenth centuries, is no longer considered open, as a subject for scientific speculation or inquiry, by many of the leading writers of the present day, they having concluded that it has been exhausted, or rather that it had terminated in the discovery that the whole question was of a verbal rather than of a substantial character, I have yet ventured to present to the Academy a paper touching it. I am not aware that any one has heretofore followed the course of experiment, and the particular reasoning from it, which will be found in this paper, though the force of the spring has often been appealed to by partisans on both sides of the controversy, as proving the truth of the standard which each attempted to establish. I shall be very willing, however, to forego all claim to originality, if what is herein presented shall be found to assist any one to a clearer understanding of a subject on which Newton and Leibnitz were divided. Notwithstanding the high authority which, in more recent times, has decided that their disagreement was rather one of words than of things, I cannot but consider it as substantial and irreconcilable, not only affecting all just conceptions of mechanical force, but leading even those who thus attempt to reconcile the opposing theories into very grave practical errors and contradictions.

Thus Dr. Lardner says ("Mechanics," chap. iv.): "If a cannon-ball were forty times the weight of a musket-ball, but the musket-ball moved with forty times the velocity

of the cannon-ball, both would strike any obstacle with the same force, and would overcome the same resistance"; — a statement that denies to the musket-ball *thirty-nine fortieths* of its force. I do not cite Dr. Lardner as an authority of a very high order, but as a leading lecturer and a writer of standard systematic works. But no one will, I presume, object to Prof. John Playfair as a representative of the modern writers who hold to the merely verbal character of this controversy. He was not only, according to Lord Cockburn (in the "Edinburgh Review"), "the best philosophical writer in the English language," but he made this controversy a subject of special study; and he came to the conclusion, that, if the proper precautions were taken in limiting the vagueness and ambiguity of the *data*, there would be no difference in the practical applications of force, and "that the propositions maintained by both sides were true, and were not opposed to each other." But let us see how he succeeded in applying these not opposed theories. In his "Outlines of Natural Philosophy," his last systematic work, published many years after the assertions cited above, he says (Vol. I. p. 206): "If the sections of two streams be the same, the forces with which they will strike on planes directly opposed to them are as the squares of their velocities. For the force of a stream must be as the force of each particle and as the number of particles that strike in a given time. Now, the force of each particle is as the velocity of the fluid, and the number of particles that strike in a given time, the section being given, is also as that velocity. Therefore the whole force of the stream must be as the square of its velocity." Not only is the assertion, that "the force of each particle is as the velocity of the fluid," directly opposed to the theory of Leibnitz, but the theorem, that "the whole force of the stream must be as the square of the velocity," is equally contradicted by the experiments of Smeaton. For, according to these writers, the force of each particle must be as the square, and that of the stream as the cube, of the velocity. Again, Playfair says (on page 216 of the same volume): "If the sections of two streams are the same, their forces will be as the squares of their velocities, or as the heights due to the velocity of the water, and the effects of the machines driven by them will be as the cubes of their velocities, or as the heights due to those velocities multiplied into their square roots." That is, *forces* which are known to us only as *causes* produce *effects* as much greater than themselves as the cube of a number is greater than its square.

With such instances of substantial and radical error, from substituting the conclusions of one theory for those of the other, how can it be said that the difference is merely verbal, or "that the propositions maintained by both sides were true, and were not opposed to each other"?

Again, in the late "Life of Newton" by Sir David Brewster, it is stated, that "Poleni

had published an experiment which he considered as proving Leibnitz's assertion that the force of moving bodies is proportional to the square of the velocity, and not, *as is commonly thought*, to the simple velocity. Dr. Pemberton saw its insufficiency, and drew up a *refutation* of it." This being "communicated to Sir Isaac, he was so well pleased with it, that he called upon Pemberton at his lodgings, and showed him a refutation of Poleni, by himself, grounded upon other principles." This *refutation*, as it is called, is published in the "Philosophical Transactions," and is intended to support in its fullest extent the Newtonian measure of force, viz. that of the simple velocity, against the measure proposed by Leibnitz. Here then we have Sir David Brewster, one of the greatest of living names in mechanical science, in one of his latest works, asserting that the force of a moving body *is commonly thought* to be as its velocity *simply*, and that the assertion of Leibnitz that the force is proportional to the square of the velocity was *refuted* by Dr. Pemberton, and again by Newton himself.

While a question of this vital character, affecting all the conceptions and many of the computations of force, is in this contradictory and cloudy state, ought scientific men to rest upon it, or to suffer it to rest, as a closed subject? The labor of preparing the following paper shows my own opinion upon this question.

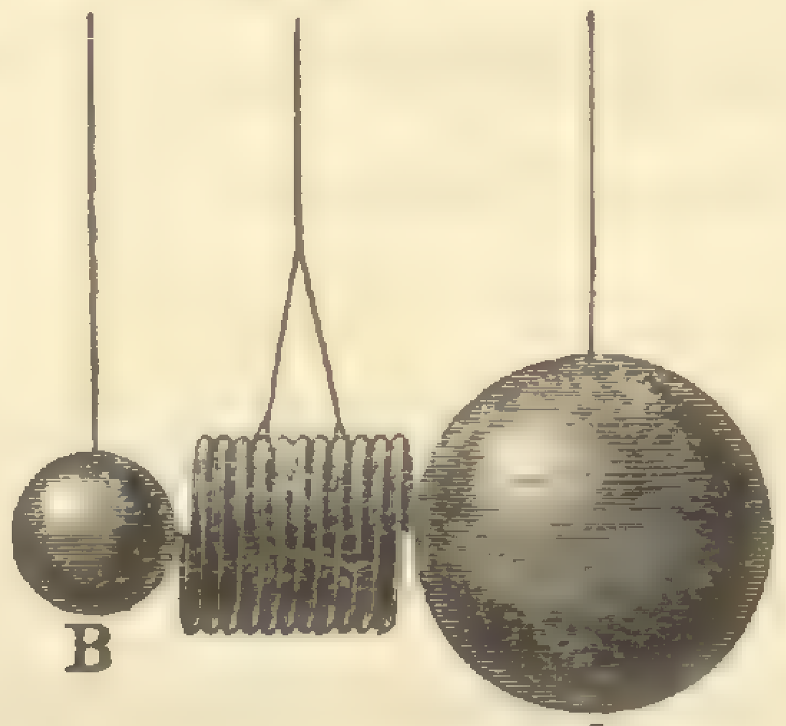
It may be well, perhaps, before opening the particular course of investigation pursued in this paper, to state briefly the precise matter that formed the subject of this renowned controversy. Suppose, then, a body, as a stone, A, of a certain mass, to be thrown in any direction in space, with a certain velocity, it must move onward with a certain force.* Now if another stone, B, having twice the mass of A, be thrown with the same velocity that was given to A, it must move with twice the force of A; for we may divide B so as to form two stones, each of which shall have a mass equal to that of A, and if thrown with the velocity of A, they must each have the force of A, and if each separately has the force of A, both, united to form B, must have twice the force of A. This is substantially the mode of reasoning used by Galileo to show that the mass of a body could not alter the velocity with which it would descend by its weight, when unsupported, to the earth; and it follows from this, that under a given velocity the forces of all bodies must be directly as their masses. If, however, instead of throwing different masses with one and the same velocity, we throw one and the same mass with different velocities, we search in vain for any reasoning of this simple

* *Force* is the unknown cause by which a body resists change from, or produces change in, another body. *Synonyme*, Power. I shall avoid, if possible, the use of the words *momentum*, *vis mortua*, and *vis viva*, as they are often used and understood in such vague and indefinite senses as to obscure rather than to give any clearness to our conceptions in an inquiry like this.

and decisive kind to prove that the forces must be as the velocities, or to show the relation that one must bear to the other. For while we can thus unite two distinct masses, making them to coexist under a common velocity, we cannot unite two distinct velocities, making them to coexist in a common mass. With the hope, then, of aiding to form a clearer conception of this subject, let me propose the following experiment.

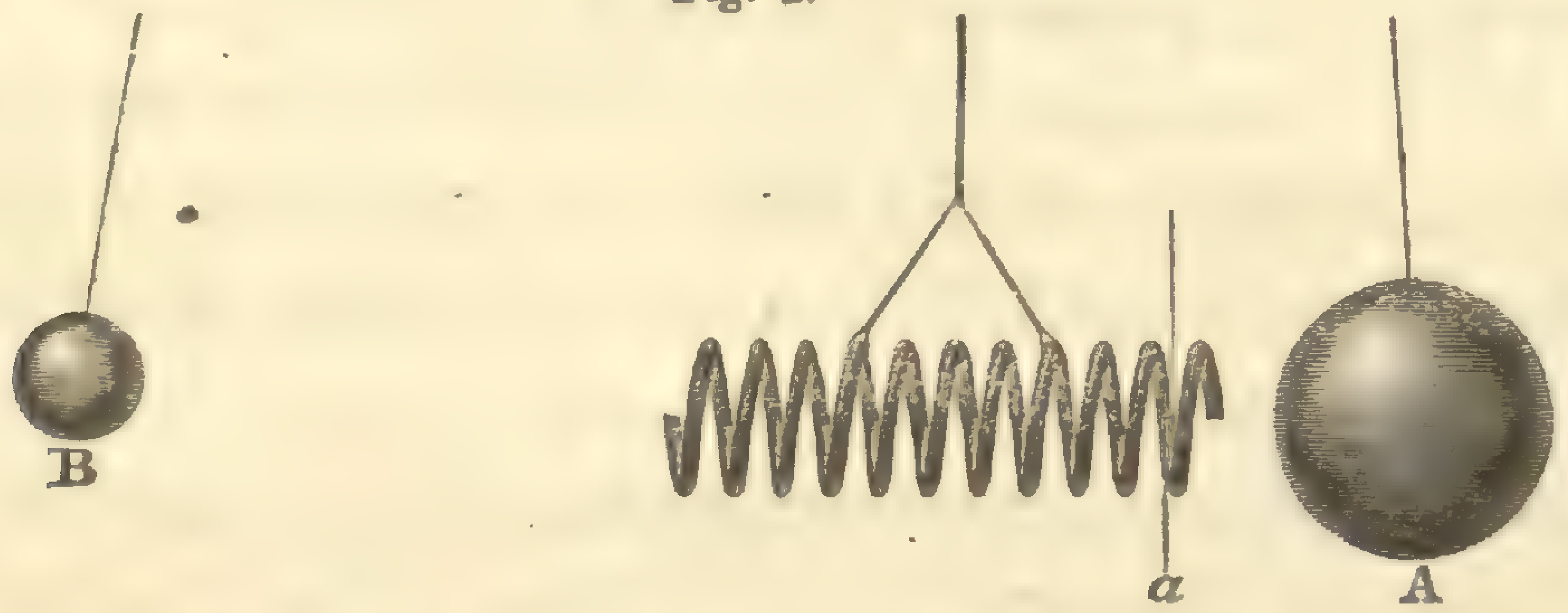
Take a spiral spring, formed of eleven turns of wire, coiled so as to leave an open space between each turn of the coil (as in Fig. 2). Let this coil be then pressed together as in Fig. 1, and place against its ends respectively the weights A and

Fig. 1.



B, suspended by cords, like pendulums. Let the weight of A be 10 pounds and the weight of B be 1 pound. On releasing the spring from its constrained condition it recovers, under the operation of its elasticity, its original form as shown in Fig. 2, while the masses A and B are thrown, one to the right and one to the left, with velocities inversely as their masses, namely, A with a velocity of 1, and B with a velocity of 10. All the force which had been applied to compress the spring,

Fig. 2.



from whatever source it was derived, and which existed in the spring's elasticity, has now passed away from the spring, and been exhausted in giving motion to A and B. It has overcome, in those bodies, to a certain extent, their state of rest, and the force, *vis inertiæ*, with which they resisted all change of that state; and those bodies together now possess a force of motion, or inertia of motion, equal to the force of elasticity given out from the spring. We may therefore conceive that the force of elasticity in the spring has been transferred to A and B in the form of

the force of the inertia of motion. This conception, while it violates no fact or result of experiment, will aid us in explaining them all.

The question now is, How much of this force has gone to A, and how much to B? Or, What is the force of A and of B respectively, at the instant they are discharged from the spring? One party in the controversy, who array themselves under the great name of Newton, determine the force of each by multiplying its mass by its velocity, simply, and find A, mass 10, multiplied by its velocity 1, to be 10; and B, mass 1, multiplied by its velocity 10, to be 10. That is, the force of the spring is equally distributed between the two bodies. They hold that this must be so of necessity; for the spring during its action pressed equally to the right and to the left, equally against the bodies A and B. This pressure was continued an equal time upon both bodies, namely, during all the time of the spring's action. How is it possible then, say they, that a greater effect has been produced in one direction than in the other?

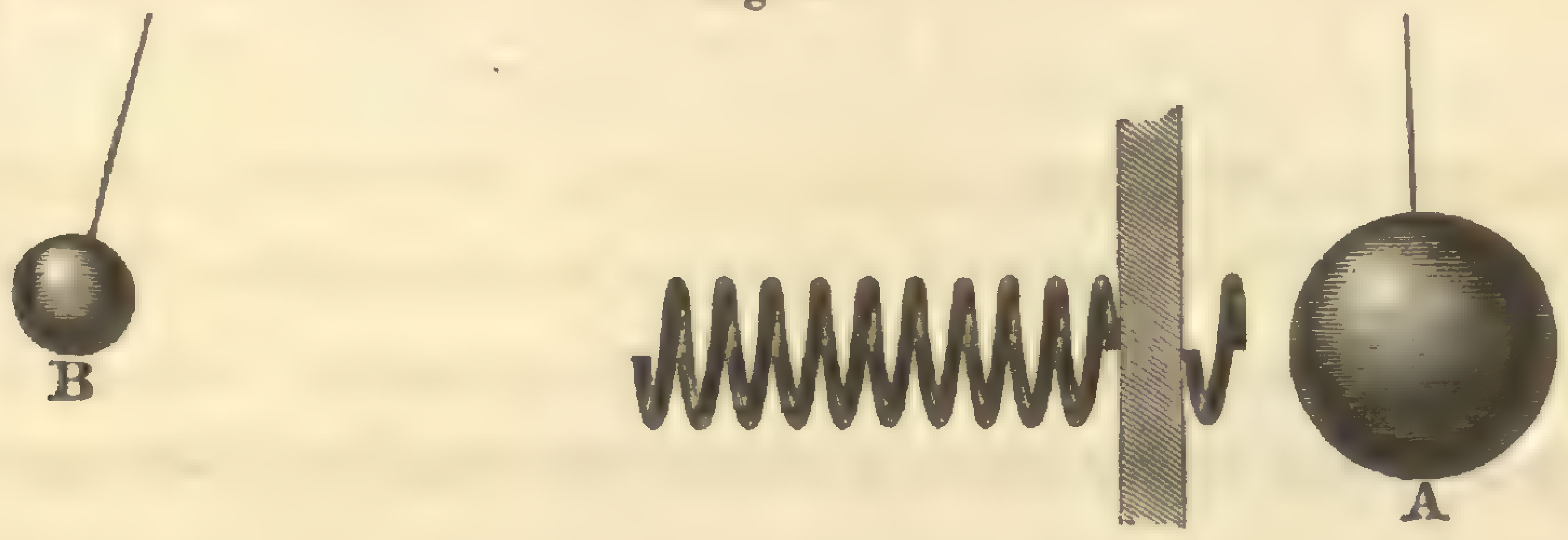
This affirmation that the action is equal upon both bodies may be held as not merely derived from, but as constituting the substance of, Newton's Third Law, which asserts that "to every action there is always opposed an equal reaction: or the mutual actions of two bodies upon each other are always equal, and directed to contrary parts"; and it is not to be denied that, so far as pressure constitutes action, this has been fully established by his citation of instances under this Third Law. But it by no means follows, because the spring maintains a like pressure by both its ends during the act of extending itself, that therefore its force is transferred equally to both bodies. The velocity with which this pressure overcomes the resistance opposed to it must be regarded, as well as the pressure itself; and indeed the whole controversy lies in determining the value that belongs to the velocity as one of the factors by which the force is produced; that is, whether this factor shall be taken in its simple form, a value clearly assigned to it by Newton in the Corollaries and Scholium of his Third Law; or whether a higher value, as its square, shall be given to it, as was first proposed by Leibnitz. Let us then see if, by tracing the course in which the spring elongates itself under different conditions, we can increase our knowledge of the transference of its force. By an examination of this subject, we shall find *that the spring acts upon each body with a velocity proportional to the resistance that it receives from the opposite body;* and we shall find *that, as we increase the mass of either body, the effect produced upon the opposite body will be increased.* Thus, if we add to the mass of B, until it becomes equal to that of A, and let the spring expand as before, the velocities of A and B will be equal; the velocity of A being more than double (as $\sqrt{5.5}$ to $\sqrt{1}$) what it was before the size of B was increased. The force expended, namely, the elastic force

of the spring, has been the same in both cases. Will it be said that it has been distributed in the same proportion to the two bodies, when A, the mass of which has not been changed, has had its velocity increased in this essential degree? And yet the Newtonians would make it the same; namely, half to each body in both instances.

We may, I think, obtain a clear conception of the action of the spring, if we consider it as depending, for its effect on each body, upon the degree of immobility which it finds in the opposite body; and hence *the force communicated to each body will depend upon the resistance of the inertia of the opposite body;* or, *through the action of the spring, the inertia of rest in each body is transferred as an active force in the motion of the opposite body.* In the case before us, the body A having an inertia 10 times as great as that of B, the force communicated to B by the spring is 10 times as great as the force communicated to A. To show this more clearly, let us attend to the exact course of the action of the spring. It will be found, if proper means be taken to mark the motion of the spring (Fig. 1) in its course of extending itself, that, during this extension, 10 of the rings of which it is composed open to the left, in the direction of B's motion, and only one in the direction of A, while the point *a* (Fig. 2) has remained at rest. The spring has acted from a plane, passing through the point *a*, as from a base, to the right and to the left. Now will any one say, that, when 10 out of 11 parts of the spring have acted wholly in the direction of B, the effect of the spring has been equally distributed between A and B?

Suppose we cut the spring in two at the point *a*, and fix the cut end of the larger part to an immovable plane, as in Fig. 3, and, placing the ball B against it when com-

Fig. 3.



pressed, suffer it to extend itself against B. The velocity of motion that it will communicate to B will be precisely equal to that produced under the conditions of Figs. 1 and 2; and if we take the remaining coil of the spring, and fix it to the opposite side of the plane, as in Fig. 3, and suffer it to extend itself, it will produce the same motion in A that was produced in the first experiment. Now it must be evident that the 10 rings of the spring contain 10 times as much elastic force as the 1 ring, and that, as no motion whatever is communicated to the plane by their action, all the force of each

spring must be communicated to the bodies A and B, against which they act respectively; and as these forces are to each other as 1 to 10, so the forces of A and B must be as 1 to 10. But the velocities of A and B are to each other the same that they were in the first experiment. Hence it follows, that the forces produced in A and B by the unbending of the spring in the first experiment were not equal, but that B received 10 parts of the force and A 1 part; and this distribution corresponds exactly with the product of the mass into the square of its velocity.

For the mass of A = 10 and its velocity = 1; then $10 \times 1^2 = 10$ for the force of A; and the mass of B = 1 and its velocity = 10; then $1 \times 10^2 = 100$ for the force of B.

We shall find, moreover, that the forces of A and B, under the velocities produced by the action of the spring, are to each other inversely as the masses of A and B; that is, at the instant that they leave the spring,

Force of A : Force of B : : Mass of B : Mass of A.

Or, the force of B is as much greater than the force of A as the mass of A is greater than the mass of B. Again, if we neglect entirely the masses of A and B, or the quantity of the mass in each, we shall find that their forces are to each other as their velocities directly, and not as the squares of their velocities. Thus, we have found the force of B at the instant that it leaves the spring to be ten times as great as that of A. This was found by multiplying the mass of each into the square of its velocity. But the velocity of B is ten times as great as that of A. If therefore we neglect the masses, as factors, with both bodies, and take the force of each, not as the square of its velocity, but as its velocity simply, we have the same comparative results; that is,

Force of B : Force of A : : Velocity of B : Velocity of A.*

This last statement is not given as favoring the Newtonian measure of force. For the mass of the body is, in that, always taken as an element or factor of the force, and it can be struck out only in a case like the one here stated; where, on striking it out, the value of another factor of the force, namely the velocity, is evolved from the square to its simple power.

It cannot fail to be understood, that whenever two bodies, as A and B in the preceding example, receive the action of elasticity impelling them in opposite directions, the neutral point, as at *a*, Fig. 2, will be placed so as to divide the elastic force into two parts, having the same proportion to each other that the parts into which a line connecting the centres of gravity of the two bodies will be divided by their common

* Indeed, this amounts to no more than dividing the two sides of an equation by the same number.

centre of gravity. Thus in the example herein given, if A contained 100 times the mass of B, the spring would be divided by the point *a* so as to give 1 part to A and 100 parts to B; and if the mass of A be made infinite with regard to B, so as to be immovable, as in the plane, Fig. 3, the point *a* coincides with the end of the spring, and all the force is communicated to B.

A very striking example for illustrating the principles of this analysis, and displaying the force of elasticity in its highest form, may be imagined under the following order of preparation. Divide the charge of powder, intended for a piece of ordnance, by a diaphragm of iron, or any substance that will stand the heat, no matter how light and thin it be, into two parts, that shall be to each other as the weight of the gun is to that of the ball. Load the piece by placing the end of the cartridge containing the smaller portion of the charge at the bottom of the chamber, the ball being placed over the larger portion of the charge. Now if the fire be communicated to both parts of the charge at the same instant, the diaphragm must, however light, remain perfectly stationary in space, being subjected to equal pressures in opposite directions upon its two sides, while the gun and the ball are driven from it in opposite directions, with velocities inversely as their weights. Here, as the cannon is often 200 times as heavy as the ball, the quantity of powder before the diaphragm, and actually expended in producing the motion of the ball, is 200 times as great as that expended in producing the motion or recoil of the gun, though the pressure upon both is the same in intensity and in time; but the quantity of the force communicated to the ball must be, under these conditions, directly as the powder expended to produce it; and yet if we take the force of the ball and that of the gun in its recoil, respectively, as the product of the mass into its velocity simply, we shall make them equal, one to the other; that is, 1 oz. of powder acting from one side of a plane, equal to 200 oz. acting from its opposite side. But, by the measure of the square of the velocity, we have, mass of ball 1, velocity 200, and $1 \times 200^2 = 40{,}000$ for the force of the ball; mass of gun 200, velocity 1, and $200 \times 1^2 = 200$ for the force of the gun's recoil; which corresponds exactly with the expenditure of the powder. It may again be observed that these forces correspond, inversely, with the masses; for $200 : 40{,}000 :: 1 : 200$.

It can hardly be necessary to remark, that in any of the preceding instances we may reverse the direction of the motion, and consider the bodies as made to approach towards each other, rather than to recede from each other. Thus if A and B, when placed asunder as in Fig. 2, are drawn towards each other by a distended spring, or by any kind of attraction, or gravitation, inherent in the bodies themselves, the force excited in, or transferred to, each will be inversely as the masses of the bodies

respectively, and this will be the case whether the elastic or attractive force be constant or variable. Hence, if the orbital motions of a satellite and its primary were destroyed, they would approach their common centre of gravity with forces *directly* as their velocities and *inversely* as their masses (*see* p. 367); and if another body were placed at their point of meeting, such body would receive a shock from the satellite as much greater than that received from the primary, as the velocity of the satellite was greater than that of the primary, or as the mass of the primary was greater than that of the satellite.

Hence in all those operations in the arts by which the form of unelastic bodies is changed by collision or percussion, as in the action of the hammer or axe, the efficiency of the instrument depends upon the inertia of the body against which it acts. Thus, if a block or anvil be suspended by a chain, or made to rest upon a spring, and a piece of lead or any soft and unelastic body be placed against or upon it and struck by a hammer, the force of the hammer will be divided between the lead and the bed or anvil; that is, in changing the form of the lead, and in giving motion to it and the anvil; and the distribution of the force, or the proportions which go to the different bodies involved in the action, may be found as follows:—

Let the mass of the hammer $= m$.
Its velocity before the blow $= v$.
Its velocity after the blow $= v'$.
The mass of the bodies struck $= m'$.
Velocity after the stroke $= v''$.

Then the *force* of the hammer before the stroke will be $m v^2$. Of this force there will remain in the motion of the masses after the stroke

$$m v'^2 + m' v''^2$$

and $m v^2 - m v'^2 - m' v''^2$ must be *absorbed* in changing the form of the lead.

If we neglect entirely the effect of elasticity, which we may do for most practical purposes, in both masses, then when m and m' are equal, one quarter of the force will remain in the motion of m, one quarter will be communicated to produce motion in m', and one half will go to change the form of the soft body. So, if the mass of m' be infinitely greater than that of m, or, not being greater, if m' be made to move in a direction opposite to the motion of m, and with a velocity such that m' and m remain at rest after the collision, then the whole force will be absorbed in changing the form of the soft body.

What is here stated may be applied to the whole subject of percussion or collision.

XIV.

Remarks on Specie Reserves and Bank Deposits.

By FRANCIS BOWEN,

ALFORD PROFESSOR OF MORAL PHILOSOPHY AND POLITICAL ECONOMY IN HARVARD COLLEGE.

[*Communicated to the Academy, November* 31, 1861.]

The question is, whether any regulation of the amount of the specie reserves in banks will avert, postpone, or alleviate a commercial crisis, and the suspension of specie payments by the banks, which is a frequent consequence of such a crisis.

The old theory upon this subject is, that a crisis is the result of an undue expansion of the bank circulation, leading first to a general enhancement of prices, and then to an export of specie; that this export diminishes the specie reserves, and thereby obliges the banks, for their own security, to contract the circulation, making it as much too small as it formerly was too large, and thus necessitating what is called "a scarcity of money," — that is, a fall of prices, a rise of interest, increasing difficulty in the payment of debts, and general distress and bankruptcy. The conclusion is, that legislation is necessary to compel the banks always to retain on hand a certain considerable amount of specie reserve, proportioned to their circulation alone, or to their circulation and deposits united; and that this restriction will prevent them from issuing too large an amount of bank-bills in prosperous times, and will better enable them to meet a drain of specie when it comes, without unduly or suddenly contracting the circulation.

But this theory, after prevailing in the commercial and legislative world for about half a century, and doing a vast amount of mischief, has at length been so far refuted, both by reasoning and experience, that it is now seldom mentioned except in documents which have rather a political than a commercial or scientific character. To mention only a few of the decisive considerations against it: —

1. The banks *cannot* expand their circulation, even if they would. Every bank cashier knows, that, if he issues an unusually large amount in bills one day, there will be a proportionally large reflux of them, both that day and the succeeding one, mostly

through the Clearing House, but in part by presentation or payment at his own counter. He is just as sure of this as he is that, if he goes out in the rain without an umbrella, he will be wet. And as the undue issue can be made only by discounting notes which have some weeks or months to run, while the reflux, taking place within twenty-four hours, can be met only out of the ordinary funds, including the specie reserve, thus at once crippling his means and endangering his credit, he will take good care not to make any such issue, and will even resist the pressing solicitations of his best customers, in order to avoid it.* The exceptions to this rule, growing out of the irregular and even fraudulent practice of discounting liberally to individuals who, doing business at a distance, will send off the bills on a long journey, whence they

* Extracts from the evidence given to a Committee of the House of Commons, in March, 1858, by James Bristow, director of the Northern Banking Company of Belfast, and representing before the Committee all the Belfast banks.

"I have been practically acquainted with the business of issuing [bank] notes upwards of forty years."

"Is it your opinion, from your experience, that your bank, or any other bank, have it in their power to increase the issue of notes at their pleasure? — Certainly not.

"Any increase of notes beyond that which was absolutely required for the uses of the community would be returned as rapidly as they were issued? — They would.

"As long as you have deposits payable on demand, and you are issuers of notes, can you, by any action of your own, restrict or reduce the quantity of notes in circulation? — You can restrict it by not discounting bills; but you must be prepared to issue something in payment of your deposits.

"If you were to attempt to restrict by not discounting bills, it would produce an action upon your deposits? — Decidedly.

"And if you were not prepared to meet that action by your notes, you must do so by coin or by some other means? — Yes.

"You cannot, therefore, influence in any way the actual amount of currency, whether of notes or of coin, or the two together, in the hands of the public? — Not in any way, I believe. I never could discover a way in which I could do it.

"And that is the conclusion to which you have come from a long experience, and having thought upon and observed the matter? — It is."

"As a banker, would you ever feel justified in making an advance if the person to whom you were going to make it were willing to take your notes, which advance you would not be justified in making if he were to demand coin? — Never.

"You would feel that it would be unsafe banking, and contrary to all rule, if you were to make an advance in notes which you could not make in sovereigns? — Decidedly.

"On the ground that you would know, that if the notes were not required, they would come back upon you for payment immediately? — I look upon all advances as made from capital; they do not increase our circulation.

"And practically speaking, whether your advances are large or small, that fact, for the time being, has little or no effect upon the amount of your circulation? — It has not."

cannot return for several days; or to those who, employing many hands, will pay out to them small sums in small bills, which, thus passing into the general circulation, cannot be collected and brought back at least for several days, — these exceptional cases, I say, besides being too few and small to be of much account any way, also operate only to expand the circulation of a few banks through contracting to an equal extent the circulation of others, thus leaving the aggregate circulation of all the banks, taken collectively, just what it was.

2. The circulation is not expanded in times of prosperity and ease in the money market, being then even lower than usual.

3. As a consequence of 2, the circulation is not contracted during a period of pressure, but is then almost invariably about ten per cent larger than when no pressure exists.*

4. Money crises may be, and have been, as frequent and severe in countries (California and Australia, for instance) where no banks of circulation existed, and where, consequently, no expansion or contraction of bank currency was possible, as here in Massachusetts, where we have a surfeit of banks.

5. The characteristic feature of a crisis in the money-market is not a scarcity of money in circulation, whether paper or metallic, but a deficiency of credit. There is money enough, — there is as much money as ever, and even more, as we have just shown; but the owners of it, through a want of confidence, will not lend it; some of them will not lend at all, others only at usurious rates. The relative abundance or scarcity of money, as such, does not even affect the rate of interest; for, paradoxical as the assertion may seem, money neither yields profit nor pays interest. In whose possession soever it may be, private person or corporation, it forms a part of his *dead capital*, and therefore he always aims to get along with as little of it as possible. What really yields interest is the merchandise or property purchased with the money, and retained in possession of the borrower during the period of the loan, while the money obtained through that loan is paid away, usually on the very day on which it is received.

6. The undue expansion of credit is not produced by a previous undue expansion of the currency. Rather the reverse is true. A previous expansion of credit produces ultimately, or after some time, an expansion, relatively a small expansion, of the cur-

* That this is the general result is proved by statistics, as any one may see by examining the bank returns. But as will be shown hereafter, there is one cause which tends to lessen the circulation during a crisis. The operation of this cause, however, is limited and trifling in amount, and is therefore overborne and concealed by the more general tendency to an expansion under such circumstances.

rency. When credit is good, — that is, when the money-market is said to be easy, — every merchant who wishes to extend his business can make purchases, almost to an unlimited extent, without borrowing or paying any money whatever. And the effect of the purchases thus made, added to the force of his example, is to raise prices. Two merchants, A and B, for instance, can buy merchandise to any extent on six or eight months' credit; and the effect of their heavy purchases will be, within a week, perhaps within a day, to induce C and D also to buy largely on equally prolonged credit, and thus to raise prices still higher. This enhanced price may tempt A and B to sell long before their own term of credit has expired, and on credit equally prolonged, to other parties; and then, considering the profits on this transaction as already accrued, to make other purchases on time, and to a larger amount, of other kinds of merchandise. The process may be carried on indefinitely by E, F, G, and so on, through all the letters of the alphabet. In this way, before six months have expired from the date of the original purchase, that is, before the first note has become due, and thereby first created an occasion for the use of any money whatever, a huge pile of indebtedness may have been created, and prices raised to that giddy elevation whence all experience shows that a speedy and precipitous fall is inevitable.

7. The notes are finally paid, if paid at all, to a great extent, without the use of any money whatever, but merely by the transfer of deposits on the bank-books from the credit of one person to that of another.*

* Robert Slater, of the firm of Morrison, Dillon, & Co., London, "one of the largest houses, as warehousemen, in the country," testified before a Committee of the House of Commons: — "Our cash operations extend over several millions [of pounds] a year." He made an analysis of the operations of this firm in 1856, in order to lay before the Committee "very strong evidence of the small proportion which the Bank of England notes bear to the general amount of the circulation of the kingdom. We received, in the course of the year 1856, certain moneys reduced to the total of £ 1,000,000 in the following proportions: in bankers' drafts and mercantile bills of exchange, payable after date, £ 533,596; in checks on bankers payable on demand, £ 357,715; in country bankers' notes, £ 9,627; these three sums amount together to £ 900,938. We received in Bank of England notes, for the same period, £ 68,554; in gold, £ 28,089; in silver and copper, £ 1,486; in post-office orders, £ 933; these four sums amount together to £ 99,062, being with the previous £ 900,938, formed of bankers' drafts, of checks, of country bank-notes, and those other matters, the £ 1,000,000 of receipts received by our house. We paid by bills of exchange payable after date, £ 302,674; by checks upon a London banker, £ 663,672; together, £ 966,346; we paid by Bank of England notes, £ 22,743; by gold, £ 9,427; by silver and copper, £ 1,484; being £ 33,654, against £ 966,346 by bills of exchange and checks, making together the sum of £ 1,000,000 of payments."

"Under a normal state of things, when there is nothing to shake confidence, I think you state that the bank-note is scarcely perceptibly required, but that balances are paid through those various economizing modes which have suggested themselves of late years in the shape of checks and bills of exchange? — Precisely so;

If there is any force in these considerations, any attempt to avert or palliate the evils of a commercial crisis through abridging and strengthening the paper currency, by laws requiring the banks to increase their permanent specie reserves, is not only futile, but ridiculous. There is no relation between the proposed means and the end. We might as well build more school-houses in the hope of lessening the frequency and violence of snow-storms.

But I go farther. Such laws are not merely useless and absurd; they are positively injurious. It is a mere truism to say, that a specie reserve can be of no service, except it may, on an emergency, be used, or actually applied, to redeem the bills or other obligations of the bank. A reserve of *two* millions, which can be paid out, if necessary, either to redeem bills or to lessen a pressure in the money-market, is surely better than a reserve of *ten* millions confined by law forever within the bank-vaults. When the confidence of the community in the currency is shaken, there may be more virtue in hard dollars than in paper dollars to allay the panic; but it is not a virtue which will sweat through the stone walls and iron doors of a bank-vault or a Sub-Treasury. The superstition which hopes to avert a crisis through the mere *presence* of specie in the country, though any *use* of it is prohibited by law, is nearly akin to the more vulgar superstition which treats a Bible as an amulet, and hangs it around the neck, or puts it under the pillow, as a means of driving off the Devil. Yet the English law of 1844, separating the department of issue from that of banking in the Bank of England, authorizes fourteen millions of circulation based on the fourteen millions of government debt owned by the Bank; and forbids the issue of bank-notes beyond this amount, except on the basis, and to the extent, of the specie reserve in actual possession. The average circulation of the Bank being about twenty millions, its ordinary basis is fourteen millions due from the government and six millions of specie in the vaults. Time soon showed how much utility there was in this vast reserve, which by law could not be touched. In 1847, only three years after the passage of the law, there occurred a severe commercial crisis. A failure of the crops made it necessary to export gold to buy corn; more bank-notes were required, as is usual under such circumstances, the circulation ran up to twenty-one millions, and the law then augmented the evil by rendering it necessary to add one million to the useless specie reserve. Still the drain of gold continued, and it could be met only

that is the time when the Bank reserve is always at its highest, because there is the smallest demand for bank-notes.

"Then the system, as it is generally carried on, is based upon confidence, I presume? — Entirely so.

"Theoretically upon gold, but practically upon confidence? — Chiefly upon confidence."

by diminishing the reserve of notes usually held in the banking department. This was done till the funds of the banking department were wellnigh exhausted, and the Bank was in the ludicrous condition of being on the verge of stopping payment with nearly seven millions of pounds sterling in specie in its vaults, which the law forbade it to touch. The ministry then stepped forward, and authorized the Bank Directors to break the law, by issuing more notes without giving security by imprisoning more specie; promising that a bill of indemnity for this irregular proceeding should be passed at the next session of Parliament. This was done, confidence was immediately restored, and the pressure ceased, even before the Bank had had time to exercise its extraordinary powers. Ten years afterwards, during the crisis of 1857, the same cycle of events was repeated. Again the Bank was on the point of bankruptcy, though it had six or seven millions of pounds in specie, which it was forbidden to use; again the ministry interfered with a letter of license authorizing a breach of the law, more notes were issued without any augmentation of the specie, and the panic then quickly subsided. The law still remains upon the statute-book, but it can hardly be said to continue in force, as it is always broken whenever an occasion for its exercise arises.

Our law here in Massachusetts is not so suicidal in its operation as the English law; and yet it is worse than useless. For in ordinary times, when the money-market is said to be easy, the law is practically inoperative, as it only enjoins upon the banks to do that which their own convenience and a due regard to their own credit would inevitably lead them to do, even if the law did not exist. On the other hand, in a time of pressure and distress, when the banks ought to be able to use every dollar of their resources in order to avert impending bankruptcy, the law steps in and locks up fifteen per cent of their immediately available funds, saying that no portion of this reserve, usually amounting in Boston alone to about four millions, shall be used except under the penalty of ceasing to make any discounts, — a penalty which might, and probably would, withdraw ten or twelve millions from the circulation, thereby intensely aggravating the pressure at the most critical moment, before the four millions of specie would be exhausted. The English law makes the specie reserve available only for the redemption of the circulation, leaving the deposits wholly unprovided for, and thereby subjecting the bank to bankruptcy through a comparatively moderate reduction of the deposits. The Massachusetts law makes the reserve equally available for redeeming the circulation *and* deposits, and is so far wiser than the English enactment; but when the reserve has fallen to less than fifteen per cent of this joint liability, the prohibition of discounts, *if enforced*, would make an immediate suspension of specie payments, or of any payments, inevitable. During the severe pressure which occurred in the autumn of 1860, the

banks had sense and resolution enough to break this law, and they were never even blamed for the transgression. In short, to fix an arbitrary limit to a specie reserve, below which it shall not be reduced under any circumstances, is about as reasonable as it would be to attempt to provide against a famine by enacting that the bakers should always keep on hand a reserve of flour, enough at least for a fortnight's consumption; which is probably no more than what they do of their own accord, when no scarcity is apprehended. But if a famine should actually happen, I apprehend the fortnight's supply would find its way to the oven in spite of the law; and with good reason, for before it was exhausted, the ships or the cars would bring another supply. If the legislature must meddle at all, the law ought to establish a specie reserve on the principle of a sliding scale, requiring the reserve to be, say twenty per cent of the aggregate immediate liabilities, whenever the banks are willing to discount at as low a rate as six per cent, and allowing two per cent to be abated from this reserve for every addition of one per cent to the rate of interest. Under such a law, the reserve would be exhausted only when the rate of interest had risen to sixteen per cent; and when that is the case, the banks ought to break, and all payments ought to be stopped, till the panic has ceased.

The course of the discussion has led us incidentally to see how a vast amount of indebtedness is created, and how prices are consequently raised, without any antecedent enlargement of the currency, but simply by selling merchandise and real estate on credit. And this brings us naturally to another and more difficult problem, — to consider *what is the real medium of payment when these debts are duly discharged at maturity.* The question, it should be observed, does not concern the ordinary petty transactions of every-day life, in which small purchases and small debts are certainly cancelled by the actual payment of money, the coin or bank-bills, however, being immediately used to effect a transfer of merchandise or property. We here refer only to the payments of considerable amount, which balance large mercantile transactions, and which take place seemingly by the transfer of bits of paper, called checks, and by a few corresponding entries on the books of a bank. *Money*, properly so called, either in the form of specie or bank-bills, evidently has no share in cancelling this class of obligations. And it is not easy to see how a transfer even of *property* is effected. Familiar as the actual process is to every one who has had occasion to pay a note at a bank, I know not of any treatise or discussion on the subject of the currency in which the *rationale* of that process has received adequate explanation. But the nature of such transfers must be thoroughly understood, before it can be seen how far the regulation of the banks, either in the management of their specie reserves or in any other particular, can affect the course of mercantile affairs, either to hasten, postpone, or avert a commercial crisis.

The prominent feature of the case is a transfer, on the books of a bank, effected by a check, of a certain amount of deposits from the credit of one person to that of another. By procuring a discount, or having notes at maturity paid in to his order, a merchant, A, has \$20,000 standing to his credit as on deposit. His notes to B and C for \$10,000 each becoming due, he orders a transfer, through his checks, of this sum to their credit, thereby cancelling his own obligations. The deposit now stands credited to B and C; and in their turn, having notes to pay, they order its transfer to D and E. In this manner, successive transfers of this one sum, of \$20,000 on deposit, may, in the course of a week, cancel indebtedness to the amount of a quarter of a million; for at different hours of the same banking day, A may transfer it to B, B to C, and C to D; though in ordinary times, certainly, the transfer is not quite so rapid. All this practically takes place without the exchange of a dollar *in money*, whether of specie or paper; and as the average total deposit in our Boston banks alone is from eighteen to twenty millions, the mere shifting of the credit for this sum on the bank books may wipe out two or three hundred millions of indebtedness every week. The relative amount of the bank circulation or of the specie reserve has nothing to do with this result, any more than it has with the position of the planets; for the whole process might go on undisturbed, if there were not a specie dollar or a paper dollar in existence. The little complication that is caused by different merchants keeping their deposit accounts at different banks in the same city, is easily resolved. A, from the Merchants' Bank, pays his note for \$10,000 to B, at the Traders' Bank, by transferring that sum in bank-bills from the former institution to the latter, A's deposit account being debited, and B's credited, to that amount; then, on the same day, perhaps, C from the Traders' pays his note for \$10,000 to D at the Merchants', corresponding changes of credit being made. Each of the two banks now holds \$10,000 in bills of the other. At the Clearing-House, on the same day, the two banks swap back these parcels of each others' bills which they have received, and the transaction is squared all round. If any one thinks that the bank-bills, *in their specific character as bank-bills*, have any effect on the nature of the transaction, he may learn his mistake by referring to the practice in the city of New York, where the checks are not paid in bank-bills, but are merely certified as "good" by the teller of the bank on which they are drawn; thus certified, they are paid in as money at another bank; and then, at the Clearing-House, the banks swap checks instead of bank-bills.

We are now prepared to understand the phenomena of an easy or a tight money market, and the circumstances of a commercial crisis. The depositors at the banks may be divided into the debtor class and the creditor class, the former holding more

property (merchandise or real estate) than they really own, and therefore having a succession of notes to pay; the latter holding much less property than they own, and therefore having a succession of notes to be paid to them. In easy and prosperous times, when credit is good, the creditor class, unwilling, of course, that their funds should lie idle on deposit without yielding interest, lend them freely to the debtor class, receiving notes "on time," as the phrase is,—that is, at two, four, or six months. The nature of the loan is, that a deposit, (that is, a debt due on demand from a bank, and therefore just as available as specie in making purchases or paying debts,) is exchanged for a note on time from an individual, with or without collateral security or indorsement. This, indeed, is the nature of all large loans or payments; they are simply transfers of indebtedness,—exchanges of *bank debt, payable on demand*, for *private debt, due some time hence;* or *vice versa.* Whether the *bank debt* (the debt due from the bank) is in the form of a deposit or a bank-bill, is of no importance, as one is readily exchanged for the other. The creditor class lending freely, the whole body of the deposits is kept in a state of activity, being rapidly transferred from one person's credit to another, and thus cancelling without difficulty any amount of indebtedness within the week. The debtor class, thus encouraged, make larger purchases, prices rise, the creditor class with characteristic caution sell, being tempted by these prices, and thus the amount of debt due to them is increased. But the tide, having reached its flood, begins to ebb. Distrust begins and gains ground. The creditor class are less willing to exchange *immediate bank debt* for *prospective private debt*, even when tempted by high rates of interest. The deposits, instead of circulating freely, now move sluggishly, as they accumulate to the credit of the creditor class, who are now loath to lend them. Ostensibly, the condition of the banks is about the same as before. There is a trifling increase of the "loans and discounts," corresponding to a trifling increase of the "circulation," the difference in either case being too slight to affect the market perceptibly. The deposits also remain at about the same amount, or are somewhat increased. But there is this great difference, which does not appear on the face of the accounts, but is the real index of the whole difficulty. The eighteen or twenty millions of deposits, instead of circulating freely, so as to wipe off two or three hundred millions of indebtedness every week, are now accumulating in sluggish masses to the credit of the creditor class; and distress of the debtor class is the inevitable result.

Specie reserves, and other legislative precautions against over-trading, affect at best the security only of the *immediate bank debt*, which nobody distrusts, and which needs no bolstering. The real evil consists in the excessive amount of what I have called *private prospective indebtedness*, which the action of the banks has done nothing to

foster, and is powerless to relieve; and which is no more affected by the amount of the specie reserves than by the state of the weather.

To the holders of this immediate bank debt, it makes no difference whether it exists in the form of bank-notes in their pockets or safes, or in the form of deposits in the bank payable on demand. Neither does it make any difference to the bank, whether, for the debt which it owes to its depositors, it issues its promises to pay on demand in what are called bank-bills, or simply has an entry on its books that such sums on deposit are due on demand to such and such persons. At any rate, it is for the owners of the deposit, and not for the bank, to determine how much of the debt due to them shall exist in the form of bank-notes, and how much in the form of a deposit. If they have more bank-notes than they need, they pay them into the bank to increase their deposit; if they wish for more notes, they can draw out by checks, if they see fit, the whole of their deposit. But as no one deems proper, in these times, to keep any considerable sum in bank-notes in his own possession, he will not change his deposit into these notes unless he has occasion to pay a debt to some other person; and then this person, for the sake of safety and convenience, will immediately reconvert them into the deposit form by paying them back, perhaps into the same bank, perhaps into another, so that the aggregate amount of the deposits in all the banks together remains at about the same point, with very little fluctuation. Strange as it may seem, the pressure of a severe crisis serves rather to augment, than to diminish, the aggregate of deposits. Many persons of moderate means, who can afford in ordinary times to keep a small sum in bank-bills in their own possession, are now compelled to part with them, in order to pay their debts or to purchase necessaries. The bank-bills thus pass into the hands of traders, who immediately pay them into the banks, and thereby increase their deposits and somewhat diminish the active circulation.* Even if these traders have notes of their own to pay on the same day on which they receive the bills, they often prefer to lodge the bills in bank in order to increase their deposit, and then pay their note with a check, which transfers this deposit to the credit account of their creditor.

These explanations make it sufficiently evident, that deposits not only perform all the functions of money, but that they *are* money, and almost the only form of money which is used in paying debts of any considerable magnitude, or in making any payments which are large enough to be effected through the banks. In such transactions, the agency of bank-bills is as trifling, in comparison with that of the deposits, as that of silver and copper money is in proportion to that of bank-bills in the petty payments

* See note to page 372.

which do not pass through the banks. Indeed, in the larger transactions, bank-bills need not be used at all, for, as we have seen, certified checks are just as good, and far more convenient; while in the smaller ones, some specie must be used for the purposes of change.

We come now to the question, whether it is possible to make any such use of the deposits as will alleviate the pressure of a panic, or what is usually called a commercial crisis. To alleviate the crisis, we say; not to avert it, for that is impossible. Trade cannot exist without speculation, for all trade *is* speculation; and speculation cannot fail to become excessive, when credit is very easily granted, as it always must be in the period after one panic, when the creditor class find that they have large deposits lying idle, and when they consequently become eager to lend them in order to obtain interest for their accumulations. As they were desirous, during the crisis, to change their investments from prospective private debts to immediate bank debt, so now, after the crisis, they are eager to obtain good private notes, payable on interest at a future day, instead of their unproductive deposits. But when abundant credit is offered on easy terms, and prices are unusually low as another consequence of the recent pressure, merchants will make large purchases in the hope of profiting by a speedy rise of prices; and in this hope they are not disappointed, as these very purchases cause the expected rise. Others are thus incited to follow their example, and speculation again becoming excessive, a panic ensues, and the former pressure in the money market is renewed.

But the fact has not been sufficiently noticed, that the creditor class of depositors are as much affected by this panic as the debtors, and that their injudicious proceedings, when thus affected, greatly enhance the very evil which they dread. As the bill-holders, by making a run upon a bank whose credit is shaken, make the suspension inevitable which might otherwise be averted, so the creditor depositors, by allowing the notes due to them to mature without making further loans, cause many to become insolvent whose assets under ordinary circumstances would pay all their liabilities and leave a surplus. Mercantile debts are paid, as we have seen, only by a free circulation of the deposits. But when the creditor class refuse to make further loans, these deposits accumulate in sluggish masses to their own credit, being seldom transferred on the bank books to the credit of the debtor class, and every failure thus caused only enhances the difficulty. Because A cannot obtain a loan, he is unable to pay a debt to B, who is therefore also driven into insolvency; and his failure, by diminishing the receipts of C and D, obliges them also to fail. It is not unlikely that C and D may be largely indebted to the very same capitalist, or "creditor depositor," whose eagerness to change his funds from prospective private debt to immediate bank debt —

or, in other words, to enlarge the amount of deposits to his own credit — made him refuse the required loan to A, which might have saved him from failure, and thereby averted the failure of B, C, and D. Thus the capitalist, by refusing to make one loan on what he considers as doubtful security, may cause himself to lose twice as much through the subsequent failures which are thus necessitated. He can foresee this result, and act accordingly, if the chain of connection be only a short one. If, for instance, by lending $ 10,000 to A, he can see that it will enable A to pay B a note for $ 15,000, and thereby B will be enabled to pay $ 20,000 to himself, a regard for his own interest will induce him to make the loan, though on what he would otherwise regard as insufficient security. What are called "forced renewals" of a note are sufficiently common, and are of precisely this character. But if the chain of connection be a long one, extending through many persons, being unable to follow it, he is fearful that, by making this doubtful loan, he will only enable B, C, D, E, &c. to pay their notes to other capitalists, so that all the benefit will accrue to them, and the only loss will be his own.

Yet nothing can be plainer than that, if he and all other creditor capitalists were willing to incur this hazard, — acting in truth on the principles of a mutual insurance company, — if they would lend, during a pressure in the money market, to the same amount and on the same security which would satisfy them in prosperous times, — then all unnecessary failures would be averted, and both the debtor and creditor classes would be equally benefited. Suppose, for instance, there were only three creditor capitalists, X, Y, and Z, and only six debtors, whom we will designate by the first six letters of the alphabet. If X would lend to A and B, and thereby enable them to pay Y and Z; if Y would lend to C and D, and thereby enable them to pay X and Z; and if Z would lend to E and F, and thereby enable them to pay X and Y; — the pressure and the panic would be greatly alleviated, for no failures could occur except of persons who could not offer reasonable security for loans, — that is, whose debts really exceeded their assets. And these *ought* to fail; a moderate pressure in the money market, by winnowing such insolvents out of the trading community, would be a benefit rather than an injury to the whole number.

It is evident, from this analysis, that an association of all, or a greater part, of the creditor capitalists might do with perfect impunity what no one of them could accomplish without great hazard and loss. They might so far diminish the pressure and panic, that not a single merchant would be driven into insolvency by it except his undoubted means were really smaller than his liabilities. All their deposits in the various banks being thrown into a common fund to the credit of this association, loans from

this fund might be made, at the common risk, *to any extent whatever;* for any loan *out of* the fund would immediately occasion a corresponding payment *into* it of the same amount. The fund would thus be inexhaustible; for if managed with common prudence, — that is, if no loans were made except on fair security, or with reasonable prospect of repayment, — the profit or interest on the loans would suffice to pay all expenses, and still leave a reserve, or guaranty fund, which would offset the few bad debts that might be contracted.

Such an association might be called a Great Bank; but it would be one of a peculiar kind. It would be a bank performing the same function for the now existing banks, that these banks now perform for individuals; — that is, it would be, to use a mathematical expression, a bank raised to the second power, — $Bank^2$. The Bank of England, to some extent, is such an institution, as it stands in precisely this relation to all the private banks and the joint-stock banks in the city of London, all of which have deposits in the Bank of England, which is thus enabled to make further loans on the strength of these deposits, without depriving the depositing banks of the full use of their funds.* Our proposed Bank, or Association of depositors, however, would be peculiar in another respect, in that it would require neither charter nor capital, would issue no bills, and would perform no function but that of making loans and circulating deposits. It would not withdraw any funds or deposits from the present banks, but would circulate and equalize these deposits, keeping the share of each bank as strictly proportioned as it now is to its amount of business. Its functions would be very similar to those of the Clearing-House, and might perhaps be profitably added to the present operations of the Clearing-House, being conducted under the oversight of the same committee, or of one chosen by the associated depositors.

* See the evidence of Alderman Salomons, a Director of the London and Westminster Bank, which, at the close of 1857, held over £ 13,000,000 (about $ 63,000,000) of deposits.

Among these deposits, he said, were the deposits of country (provincial) banks; and the London and Westminster Bank made deposits with the Bank of England. He stated that the effect of the pressure (crisis) in November, 1857, was to induce them to increase the reserve in their own hands, and *also to increase their deposits in the Bank of England.* They did this by allowing the bills which they had discounted for the bill-brokers to mature. "About £ 5,000,000 of bills matured between November 11 and December 31." "Our deposits with the Bank of England were increased."

"You say that your discounts, either at your own counter or through the bill-brokers, are ordinarily very large, but that, at the time of severest pressure, you contracted them so far as you thought was just to your own immediate customers? — Yes; but the capital was still there, because it was at the Bank of England, and it was capable of being used for short periods; if we did not want it, others might have used it.

"In fact, it was used by the Bank of England? — Undoubtedly; I should suppose so; there is no question about it."

It appears from this explanation, that there is no good reason why persons of undoubted solvency should find it any more difficult to pay their notes at one time than at another. The fund which affords the means of paying them — i. e. the total amount of the deposits — remains without material fluctuation throughout all conditions of the money market; or rather, as we have seen, it is a little increased in a time of pressure. And the aggregate of this fund is not diminished by making payments out of it to any amount whatever; for though all commercial debts are paid *out of it*, they are by the same act paid *into it*, the operation of payment only shifting the names of the persons to whose credit a given portion of the fund is entered. But so long as the fund is owned and held (say) by a thousand different depositors, any one owner fears to lend during a crisis, lest the loan should diminish his share of the deposits, though it would thereby certainly increase the share of some other owner. But throw all the deposits into one fund, intrusted to the management of one person or one institution, and, while each depositor may still retain the entire use and direction of his own deposits, the manager of the whole may make loans to any extent without subtracting a dollar from the aggregate. To obtain a loan and therewith to pay a debt, is not to take away anything from the total amount of the deposits, but only to shift the distribution of them on the books where they are entered to the credit of different persons.

It is not proposed to withdraw any of the deposits from the individual banks in which they are now lodged. All that would be necessary is, that each depositor, still dealing with his accustomed bank, and lodging his funds there, should enter them, not to his own credit, but to the credit of the Central Association, or Great Bank, which would have the general management of the aggregate deposits. The individual depositor would then draw his check, whenever he had occasion, not upon his own bank, but upon this Great Bank, which would honor the check simply by transferring the amount to the credit of the person in whose favor it was drawn, or by certifying it as "good," in which case it would be honored by any bank to which it might be presented. Checks might be drawn, it is true, in order to obtain specie to send to foreign countries or to other cities. But the occasions for making such remittances in specie would not be more frequent, or to any greater amount, than under the present system; and the books of the Great Bank, on which each individual depositor would appear as its creditor, and each individual bank in which the deposits are actually lodged as its debtor, would render it easy for any bank to be credited for the amount of any check which it should be required to pay in specie. But vastly the larger portion and amount of the checks needing to be honored only by transferring on the books of the Great Bank a given sum from the credit of one depositor to that of another, much handling of money

and counting of bank-bills would be obviated. Bank labor would thus probably be as much economized by the proposed institution, as it has been by the establishment of a Clearing-House.

It is, perhaps, difficult to understand how the individual banks in which the deposits are actually lodged should have the full use and benefit of the funds so intrusted to them, and at the same time, the Great Bank should be able to use these deposits over again, this latter use not at all interfering with the former one. But this is only the same phenomenon which presents itself in the relation between one of the individual banks and the private depositors in it. A trader certainly does not lose the use of his surplus funds when he deposits them in a bank, but can still pay his debts with them, or draw them out by a check whenever wanted. Yet the bank also has the full benefit of them, as it employs every dollar of the average amount of its deposits in discounting notes for its own profit, experience showing that the aggregate amount of these deposited funds continues with little fluctuation, the daily withdrawals being constantly made up by fresh deposits. The private trader cannot safely put his surplus funds out of his own control for a single day, and therefore lodges them in a bank where they are payable *on demand.* The bank, then, could not safely use them if it had but *one* depositor; but having *many*, the stream which is constantly pouring into it from many sources compensates the occasional outgoes, and leaves the amount within the bank standing always at about the same level. In like manner, the Great Bank, resting on the *aggregate* deposits made in *many* individual banks, can safely make such use of the enormous fund thus placed at its disposal as no single bank could make of any fraction of it. For the deposit which is paid *out of* any individual bank may be paid *into* any other bank, and thereby so cripple the former as to compel it to stint its accommodations even to its regular customers. But, as already stated, the deposit which is paid out of the aggregate in the Great Bank *must* be immediately paid back into the same aggregate, thus leaving the institution just as strong as before. The only exception will be the comparatively rare one already noticed, a deposit being drawn down to enable the depositor to remit specie abroad or to other cities. The amount of such remittances must always be trifling in comparison with the whole amount of the deposits. Almost the sole function, at present, of the specie reserve, is to provide for such remittances; and experience has shown, that an aggregate specie reserve of five millions is amply sufficient for this end for all the Boston banks, while the aggregate deposits amount to eighteen millions.

Indeed, when it is remembered that *immediate bank debt* is the currency which affords the means of paying off private debts, it becomes evident that the arrangement here proposed will just double the amount of this currency. At present, for instance,

there are but eighteen millions of it in Boston, which the banks are bound to pay on demand to their individual depositors. After the establishment of the Great Bank, this amount will be raised to thirty-six millions; namely, eighteen millions due from the present banks to the Great Bank, and eighteen millions due from the Great Bank to the private depositors. Debts can be paid with equal facility from either moiety of this fund.

What, then, would be the inducement for private depositors to take the *trouble* — for *risk* there will be none — of causing their deposits at their accustomed banks to be entered, not to their own credit, but to the credit of this Great Bank, and of then drawing their checks upon this bank, and not upon the one in which their funds actually lodged? As long as money is plentiful, and can be had on easy terms, they will not, it is true, be profited by the arrangement. But as soon as interest rises to seven or eight per cent, under the pressure of a coming crisis, the enormous latent power of the Great Bank can be brought immediately into play, to answer all demands for loans, and thus to prevent the rate of interest from rising any higher. Any merchant or institution in good credit, or that is able to offer undoubted security, can obtain loans from it to an indefinite amount, at a rate not less than seven, and not exceeding eight per cent. I say "not less than seven"; for as long as capital is abundant, and loans can be easily obtained at the ordinary rates, it would be the height of imprudence, it would stimulate excessive speculation, and it would injure the present banks by bringing into rivalry with them the unlimited power of this giant institution, to allow the Great Bank to discount notes in ordinary times and at ordinary rates. Unhappily, a pressure in the money market is so frequent in recurrence, and does so much harm while it continues, that a sure palliative for the evil would be cheaply purchased at almost any price. The interest accruing on the loans made only in times of financial difficulty would be sufficient, as before remarked, to defray current expenses, to constitute a guaranty fund against bad debts, and perhaps to pay a small dividend to the depositors. The action of the institution, then, would be like that of a great fly-wheel in the financial community, to equalize the pressure and produce regularity of motion under all circumstances.

The Bank of England already performs to a considerable extent the functions here proposed. It operates as a great regulator, using the vast power which it possesses chiefly in times of financial distress, and being comparatively inert when the rates of interest are low. The public deposits, and those which are lodged in it by other banking institutions, are the sources of this vast power; for its capital, though large, is all lent to the government, and consequently exists only in the form of irredeemable public debt, which, in a time of difficulty, can be made available only by the sale of stock at

a heavy sacrifice. Still, its regulating power is very great, and its prompt action has often rescued, though at great peril to itself, half of the banks in the country, and a large portion of the trading community, from total bankruptcy. Indirectly its action limits the amount of the currency, and its declarations establish from time to time the rates of interest; though in this respect, of course, it follows rather than leads the action of the market. Yet its action is much feebler than it might be; for its deposits, however large, are vastly below the aggregate deposit fund of the country, and it is much hampered by its close connection with the government, and by the unwise regulation already adverted to, which establishes an arbitrary limit to its specie reserve. In so far, also, as it performs the functions of an ordinary bank, by issuing its own notes payable on demand, and holding a fixed amount of specie reserve for the redemption of them, it is not a regulator, but is itself an institution needing to be regulated.

But with all these drawbacks upon its efficiency, the relief which it affords to the trading community in times of commercial distress is very great. The crisis which occurred in the autumn of 1857 was severe and widely extended, being felt with almost equal stringency in England, Northern Germany, and the United States; and we possess the history of it in a complete and trustworthy form, through the evidence which was taken before a committee of the House of Commons early in 1858. It appears from the testimony of the Governor of the Bank of England, and others, that the Bank deems itself bound, on such emergencies, "as a public institution, to make common cause with commerce," so as "not to refuse accommodation to any person who brought good securities," and "that the notion appears to be so thoroughly ingrained in the minds of the commercial world, that, whenever you have good security, it ought to be convertible at the Bank in some shape or way, that I have very great doubt indeed whether the Bank can ever take a position to refuse to assist persons who have good commercial securities to offer." The only hard condition upon which this help is afforded is a rapid and considerable rise in the rate of interest charged, dependent upon the extent and urgency of the demand. The ordinary rate of discount, which varies in quiet times from two to three per cent, rises quickly during a period of pressure to eight, and even ten, per cent. Subject to this condition, the Bank appears in times of great pressure to discount all the unexceptionable *short* paper — i. e. paper having but a short time to run — which is offered to it, and also to make large advances to other banks upon the security of such paper which they had previously discounted.

Of course, the amount of its loans and advances during such a crisis increases very rapidly. Late in July, 1857, before any pressure began to be felt, the aggregate was

less than $7\frac{1}{2}$ millions; October 24, it was 10 millions; and on the 25th of November, it exceeded 21 millions, being an increase within one month of 11 millions sterling, or over 53 millions of dollars. A portion of the fund which enabled the Bank to make this enormous increase of the loans was supplied by the enlarged amount of bankers' deposits, which were only $2\frac{1}{2}$ millions in July, but rose to $5\frac{1}{2}$ millions late in November. The total amount of the deposits rose within the same period from 14 to $20\frac{1}{2}$ millions. The Governor stated to the Committee, as "the ordinary course, when commercial alarm is engendered, that the bankers' deposits, and even the traders' deposits, increase"; that is, "the bankers, in order to meet a possible demand upon them, strengthen their deposits at the Bank of England, *the Bank of England being the bankers' bank.*"

But if the Bank of England during a crisis, with no other help than an addition of six or seven millions to its deposits, is able to afford thus much relief to the trading community, how vastly more efficient might its action be, if aided by a greater concentration of the deposits on the plan here proposed. While the pressure was at its height in the autumn of 1857, it appears that the aggregate deposits in the three principal Joint-Stock Banks, — viz. the London and Westminster, the London Joint-Stock, and the Union, — exceeded thirty-three millions sterling. This enormous sum might have been added to the resources of the Bank of England without withdrawing a shilling of it from the institutions in which it was actually lodged; and then, with a deposit fund exceeding fifty-three millions at its command, the loans and advances might have been indefinitely increased without hazard, and even without raising the rate of interest to more than six or seven per cent. So large a deposit fund, though not equal, of course, to the aggregate of *all* the deposits made at the various banking institutions in London, amounted probably to so large a fraction of them all, that it would have been safe to expect that at least three fourths of the loans and advances made *out of it* would only occasion equivalent payments *into it*, or, in other words, that the loan would amount only to a transfer on the books from the credit of one person to that of another.

Under such a system, alarm in the mercantile community might be made to counteract the pressure in the money market, instead of being, as at present, the sole cause of that pressure. Now, when commercial distress is impending, every prudent merchant and bank director must fortify his position by increasing his deposits; and as these deposits are scattered among many institutions, every such action "ties up" a portion of the *immediate bank debt*, which is the only fund of any importance from which commercial payments can be made. The very act which lessens the peril for

the individual, augments the pressure and the danger for the public. But if, by any means, the increased deposits can be thrown into one large fund, every enlargement of this fund increases the facility of making loans, and thus, without any diminution of the individual's security, the whole trading community is protected from harm. For each merchant to increase his own deposits with a view only to his own security, is an act precisely analogous to hoarding specie when bank-notes are thought to be imperilled. Hoarding is the only source of the danger, and each particular act of it augments the risk. Bring the hoards together into one banking fund, on the principle of a mutual insurance company, and a double precaution is taken; the same act removes the source of the difficulty and augments the means of protection.

XV.

A History of the Fishes of Massachusetts.

By DAVID HUMPHREYS STORER, M. D., A. A. S.

(*Continued from Vol. VI. p.* 372.)

GENUS II. PLATESSA, Cuv.

Body rhomboidal, depressed; both eyes generally on the right side of the head, one above the other; a row of teeth in each jaw, with others on the pharyngeal bones; dorsal fin commencing over the upper eye, that fin and the anal extending nearly the whole length of the body; but neither of them joined to the tail; branchiostegous rays six.

Eyes on the Right Side of the Head.

PLATESSA PLANA, *Storer.*

The Flounder.

(PLATE XXX. FIG. 2.)

Pleuronectes planus, New York Flat-fish, MITCH., Trans. Lit. and Phil. Soc. of N. Y., I. p. 387.
Platessa plana, Flounder of Massachusetts, STORER, Report, p. 143.
" " *New York Flat-fish,* DEKAY, Report, p. 295, pl. 48, fig. 154, and pl. 49, fig. 158.
" " AYRES, Bost. Journ. Nat. Hist., IV. p. 276.
" " STORER, Mem. Amer. Acad., New Series, II. p. 476.
" " " Synopsis, p. 224.

Color. The smaller and middling-sized specimens, when first taken from the water, are of a greenish-brown tinge, more or less spotted and blotched with rusty brown. The larger individuals are of a general rusty-brown color; or a dark, blackish brown, or a dull slate-color scarcely exhibiting any spots. The left side is colorless. Pupils black, irides golden. The dorsal, anal, and caudal fins are yellowish-brown; the two former are generally blotched with darker brown. The pectorals and ventrals are of the color of the right side of the fish.

Description. The greatest depth of this species is less than half of its length exclusive of the tail. The head is about two fifths the length of the fish includ-

ing the tail. The mouth is small, the lips are fleshy. A single row of compact, prominent, incurved, trenchant teeth, slightly notched on the cutting edge, form a continuous line from the angle to the centre of each jaw. On the upper jaw is one tooth, on the lower jaw are two teeth, on the side of the jaw next the colored side. The right half of the jaws, or the half next the colored side of the fish, edentate. The eyes are large, oblong; their longest diameter less than one fifth the length of the head. The space between the eyes, which is covered with scales, at its middle portion is equal in width to about one third the long diameter of the eye.

The lateral line, commencing at the anterior inferior angle of the inferior eye, curves backwards and upwards just behind the eyes to the posterior angle of the upper eye, then passes backwards along the edge of the gill-covers to the superior angle of the operculum, from whence, after making a slight curve over the pectorals, it pursues a straight course to the tail.

The dorsal fin commences anterior to the middle of the upper eye, and gradually increases in the length of its rays towards its posterior half, when it beautifully curves to its termination, at the origin of the fleshy portion of the tail.

The pectorals are situated just beneath the posterior angle of the operculum: their height is nearly equal to half the length of the head; the central rays are bifid at their posterior extremities.

The ventrals, which are of moderate size, arise on a line just anterior to the pectorals, and their extremities project beyond the commencement of the anal fin.

At the origin of the anal fin is situated a strong spine, which is nearly concealed by the flesh.

The anal fin arises on a line with the anterior third of the pectorals, and terminates opposite the termination of the dorsal fin.

The caudal fin is rounded when expanded.

The rays of the fins are scaled, — and the extremities of those of the dorsal and anal are free.

The fin rays are as follows: — D. 61. P. 10. V. 6. A. 46 – 48. C. 17.

Length, from twelve to twenty-one inches.

Remarks. This is the most common flat-fish taken in the waters of Massachusetts. It is captured in considerable quantities throughout all the warm season of the year near the shore, from the wharves and bridges; and in the winter is speared through the ice. The finest brought to Boston market are taken from around Deer Island, — and those from that locality frequently measure from twelve

to eighteen inches. The largest specimen of this species I have ever seen measured twenty-one inches in length, and seventeen in width.

Massachusetts, STORER. Connecticut, LINSLEY, AYRES. New York, MITCHILL, DEKAY.

PLATESSA DENTATA, *Storer.*

The Flounder of New York.

(PLATE XXX. FIG. 3.)

Pleuronectes dentatus, Flounder of New York, MITCH., Trans. Lit. and Phil. Soc. of N. Y., I. p. 390.
Platessa dentatus, Flounder of New York, STORER, Report, p. 143.
" " " " DEKAY, Report, p. 298.
" " STORER, Mem. Amer. Acad., New Series, II. p. 476.
" " " Synopsis, p. 207.

Color. All the right side of the body and the fins of a uniform reddish-brown. Pupils black, irides golden.

Description. Body elongated. The length of the head to the whole length of the body, exclusive of the caudal fin, about as one to four. The eyes are situated upon the right side of the body, and placed over each other, — the upper slightly posterior, — separated by a bony ridge, covered with scales similar to those over the whole head. The longest diameter of the eye nearly equal to one sixth the length of the head. The mouth is very large, the perpendicular gape being nearly equal to two thirds the length of the head; the upper jaw projects slightly beyond the lower; both jaws are furnished with a single row of prominent, sharp teeth, separated from each other, so that when the mouth is closed the teeth of one jaw shut into the space between those of the opposite jaw; the lower jaw has a blunt, bony tubercle at the chin. The lips are small.

The lateral line is nearly straight, making only a scarcely perceptible curve over the pectoral fins.

The dorsal fin commences just over the middle of the eye, and terminates at the base of the fleshy portion of the tail; the first rays are quite short, and gradually lengthen towards the middle of the fin, whence they again diminish posteriorly.

The pectorals are subtriangular, and nearly half the length of the head.

The third and fourth rays of the ventrals are the longest; the posterior ray is very minute.

The anal fin commences on a line beneath the middle of the pectorals, and terminates opposite the dorsal fin. The edges of the dorsal and anal fins on the right side are fringed by the continuation of the whiteness of the left side upon them.

The fin rays are as follows: — D. 98. P. 11. V. 6. A. 70 – 75. C. 18.

Length, twelve to twenty-one inches.

Remarks. This species is frequently taken in the winter season at Provincetown; and is occasionally brought to Boston market. It is a sweet fish, but is not generally relished as well as the *P. plana.* It is known as the *Sand-dab.* The largest specimen I have seen, measured twenty-one inches in length, and weighed three and a half pounds.

Massachusetts, STORER. Connecticut, LINSLEY, AYRES. New York, MITCHILL, DEKAY.

PLATESSA FERRUGINEA, *Storer.*

The Rusty Flounder.

(PLATE XXX. FIG. 4.)

Platessa ferruginea, Rusty Dab, STORER, Report, p. 141, Plate II.
" " *Rusty Flat-fish,* DEKAY, Report, p. 297.
" " STORER, Mem. Amer. Acad., New Series, II. p. 476.
" " " Synopsis, p. 224.

Color. All the right side of the body is of a reddish slate color, with a tinge of green, covered with numerous large, irregularly formed ferruginous spots. The fins have the color of the body. Beneath, of a clear white, except the posterior portion in front of the caudal fin, the caudal fin, and the margins of the dorsal and anal, which are a lemon yellow. The pupils are black, the irides golden.

Description. Body elliptical. The depth of the body is rather more than one third the entire length of the fish. Its surface is roughened by the scales. The length of the head is less than one fourth the length of the fish. The mouth is small; the lips are tumid. The jaws are equal, with a row of numerous small teeth in each jaw; those upon the colored side of the upper jaw are very minute. The anterior nostril is tubular. The eyes are large, and separated by a bony ridge, which arises in front of the centre of the upper eye, (the fish being placed upon its belly with the tail towards the describer,) and, passing in front of and around that eye, goes backwards and downwards to the posterior superior angle of the operculum, where the lateral line commences. The lateral line at its origin curves upward to a height equal to about one fourth the length of the head; and at the distance of about one half the length of the head from its commencement assumes a straight course, which it pursues to the extremity of the caudal fin.

The dorsal fin arises over the anterior third of the upper orbit, and its rays gradually increase in their length towards its middle, where they are longest. This

fin terminates in front of the caudal rays at a distance equal to about one third of their height: the extremities of the rays, which are white, are free, and resemble small filaments or tentaculæ.

The pectorals are situated at the posterior angle of the operculum; the extremity of the first ray reaches the arch of the lateral line at its centre.

The ventrals are opposite the pectorals, and extend to the origin of the anal fin.

Just anterior to the anal fin is a strong horizontal spine, almost concealed by the flesh.

The anal fin commences under the posterior third of the ventral fins, and terminates on a plane with the dorsal fin: this fin is of the same form as the dorsal; like it, its longest rays are towards the centre of the fin; and the tips of the rays are free.

The caudal fin is rounded; its central rays are three fourths as long as the head.

The fin rays are as follows: — D. 84. P. 10. V. 6. A. 65. C. 16.

Length, eighteen to twenty inches.

Remarks. This species is occasionally brought to Boston market, in the winter and early spring, from the northwestern coast of Massachusetts Bay, and principally from the vicinity of Cape Ann, where it is taken in about thirty fathoms of water.

Massachusetts, STORER. New York, DEKAY.

PLATESSA GLABRA, *Storer.*

The Plaice of Massachusetts.

(PLATE XXXI. FIG. 1.)

Platessa glabra, Plaice, STORER, Proceed. Bost. Soc. Nat. Hist., I. p. 130.
" " " " Mem. Amer. Acad., New Series, II. p. 477.
" " " " Synopsis, p. 225.

Color. Above grayish, mottled with dark brown: dorsal, anal, and caudal fins reddish-yellow, with well-marked, nearly black spots, more or less oval, differing in their size. Ventrals of a light brown.

Description. Body elongated, perfectly smooth. The length of the head is rather less than one fifth of the whole length of the fish, including the tail. The eyes are prominent, not so much so, however, as in the *plana;* the inferior eye hardly in advance of the upper. The lips are fleshy. The mouth is very protractile. Numerous sharp, cylindrical, somewhat conical teeth exist in both jaws; those on

that portion of the jaw next to the colored side are the smaller. The nostrils are directly in front of the eyes; the anterior is tubular. Between the eyes is a smooth ridge, covered by the common cuticle of the head as far back as the posterior angle of the orbit of the upper eye; from this point it becomes naked and rough, and is continued back to the superior angle of the operculum, where it is much larger than at any other point, terminating obtusely; between the extremity of this and the commencement of the lateral line is a smaller bony tubercle, apparently separated from the former.

The lateral line commences just back of the outer edge of the tubercle just referred to, and continues nearly in a straight course to the posterior extremities of the caudal rays.

The dorsal fin commences above the superior anterior angle of the upper eye, and gradually increases in the height of its rays towards its posterior half, the height of the longest rays being five times that of the first rays; this fin terminates at the base of the fleshy portion of the caudal fin, its last ray being of about the same height as the first ray.

The central rays of the pectorals are bifid.

The ventral rays do not extend to the anal.

The anal fin is formed like the dorsal, and terminates on a line with it. The rays of this fin, as well as of the dorsal, are somewhat scaled.

The caudal fin is slightly rounded when expanded.

The fin rays are as follows:— D. 62. P. 9. V. 6. A. 41. C. 16.

Length, eight inches.

Remarks. This species differs from the *plana* in the smoothness of its body; in the situation of the eyes; in its less distorted mouth; in the bony ridge upon its head; in the much greater thickness of its body; in its ventral fins not reaching the anal fin; in its caudal rays being almost destitute of scales; in there being scarcely any curve at the origin of the lateral line; in the number of the dorsal and anal fin-rays; and in the rays of the fins being stouter.

Besides these external differences between this species and the *plana*, the different form of the teeth in the jaws of the two species, the absence of teeth on the hyoid bone of the *plana*, the comparative lengths of their intestinal tubes, and the difference in form of the cœcal appendices, are very striking.

This is not a common species. It is taken in company with the *plana*, and is generally known as the Plaice.

Massachusetts, Storer.

Eyes on the Left Side.

Platessa oblonga, *Dekay.*

The American Turbot.

(Plate XXXI. Fig. 2.)

Pleuronectes oblongus, Spotted Flounder, Mitchill, Trans. Lit. and Phil. Soc. of N. Y., i. p. 391.
Rhombus aquosus, Watery Flounder, Storer, Bost. Journ. Nat. Hist., i. p. 351.
" " " " " Report, p. 146.
Platessa oblonga, Oblong Flounder, Dekay, Report, p. 299, pl. 48, fig. 156.
Platessa ocellaris, Long-toothed Flounder, Dekay, Report, p. 300, pl. 47, fig. 152.
Platessa oblonga, Storer, Mem. Amer. Acad., New Series, p. 477.
" " " Synopsis, p. 225.

Color. Of a reddish-gray color, with more or less numerous circular, oval, or oblong blotches of a darker color, surrounded with a lighter margin, and also numerous white spots, which are distributed more especially at the bases of, and upon, the fins. The dorsal fin is of a lighter color than the body of the fish; its lower portion is reddish; the upper part of a leaden color; and frequently the entire fin is sprinkled with minute white spots; the extremities of the rays are tipped with white. The pectorals are transversely barred with black and white bands, and have a white blotch at their inferior base. The ventrals are light, with darker spots. The anal is similar in its color to the dorsal. The orbits, space in front of the eyes, and the jaws, are spotted with dull blue. Pupils black, irides golden. Right side of fish colorless.

Description. Body elongated, with very small, perfectly smooth scales. The depth of the body across the middle, exclusive of the fins, less than one third the length of the fish. The length of the head is rather less than one fourth the entire length of the fish. The top of the head in front of the eyes, the lower jaw, and the intermaxillaries, are perfectly smooth. The eyes are oblong, moderate in size: the upper eye is slightly back of the inferior, in a vertical line; distance between the eyes equal to the longest diameter of the eye. The mouth is situated obliquely; its gape is very large; when closed, the upper jaw projects very slightly in front of the lower; the jaws are armed with a single row of separated, quite large, sharp teeth, the front ones much the largest. A protuberance at the chin. The nostrils are double; the anterior has at its posterior edge a tubular membrane.

The lateral line, commencing in front of the posterior angle of the operculum, makes a high arch over the pectorals, and terminates in a straight line which begins at the posterior extremity of these fins; the top of this arch is a distance nearly equal to one third the length of the head above this straight line.

The dorsal fin arises on a line with the origin of the orbit of the upper eye, and extends to the fleshy portion of the tail. The extremities of the rays are free. The first rays are quite short; those at the middle and towards the posterior portion the longest; the most posterior are the shortest rays of the fin.

The pectorals are rounded when expanded.

The ventrals are very small, half the height of the pectorals; their extremities are free.

The anal fin arises just back of the origin of the ventrals, and terminates on a line with the dorsal, to which it is similar in form.

The caudal fin is large and fleshy, equal in height to the pectorals. The depth of the fleshy portion of the tail at the termination of the dorsal fin is equal in length to the caudal rays. The rays are deeply bifid. When this fin is expanded, it is rounded at its posterior extremity; when not expanded, it is convex, sometimes almost acutely pointed at its posterior centre.

The fin rays are as follows: — D. 89. P. 12. V. 6. A. 74. C. 16.

Length, fifteen to thirty inches.

Remarks. The species above described must, I think, be considered the *Platessa oblonga*, and also the *Platessa ocellaris* of Dekay. This conclusion, I conceive, is inevitable upon an examination of Dekay's descriptions and figures. A few observations upon this point may serve to settle the matter. The specimen before me has ocellated spots upon its surface, an angulated caudal fin, a prominence at the chin, and less than ninety dorsal rays.

The ocellated spots would show it to be the *P. ocellaris.* But that species, according to Dekay, has a rounded caudal fin, more than ninety dorsal rays, and a prominent chin.

The angulated caudal fin, and number of dorsal rays (less than ninety), would point it out as the *P. oblonga.* But Dr. Dekay would lead us to infer that there were never ocelli. He says, this species "is nearly uniform brown; occasionally with spots." As I have seen numbers of this species in the market at a time, they present the following characters. Some have distinct ocelli distributed over the greater portion of the body; while in others they are so dim as scarcely to be observed at all. They all have the chin prominent. They all have an angular tail when unexpanded, which is rounded when fully expanded. I have counted eighty-eight, eighty-nine, ninety, ninety-one rays in the first dorsal fin. The two species of Dekay would thus appear identical.

In a specimen I received from Provincetown, in August, 1844, both sides of the fish were equally dark-colored; the upper eye was situated directly upon the top of

the head; back of this eye was a deep notch, upon the upper edge of which, at its anterior angle, commenced the dorsal fin, as shown in the figure. (Fig. 2. b.)

This species is quite common during the summer and early part of autumn at Provincetown, and as far up the Cape as Wellfleet. It is taken along shore in very shallow water, and frequently weighs from fifteen to twenty pounds. At Provincetown it is known as the *Plaice*, in Boston market it is called the Turbot. It is an excellent fish, and is considered by judges to be fully equal to the *Rhombus maximus*, English turbot. For quite a number of years a few specimens had occasionally been yearly brought to our market, when Captain Atwood, about the year 1841, conceived the project of bringing them alive, by the cargo, in the well of his smack. For three years he succeeded quite well in disposing of several loads in this manner, — some being bought, by those who knew their value, as turbot, and others as young halibut. When, however, in the year 1844, the fishermen commenced packing in ice halibut taken upon George's Banks, and were thus enabled to keep the market supplied with that species in a state of perfect preservation, the species we are considering could not be sold. In the latter part of 1847, Captain Atwood brought to Boston a smack load of most excellent turbot, alive, and sold but two hundred-weight, — the remainder died upon his hands, — while species of infinitely inferior quality met with a ready sale in the market.

Massachusetts, STORER. New York, MITCHILL, DEKAY.

PLATESSA QUADROCELLATA, *Storer*.

The Four-spotted Flounder.

(PLATE XXXI. FIG. 3.)

Platessa quadrocellata, STORER, Proceed. of Bost. Soc. Nat. Hist., II. p. 242, 1847.

Color. When just taken, the left side of this species is of a gray color, thickly spotted with brown, so as to appear almost confluent, including all of the fins. Upon the posterior half of the body, just beneath the dorsal fin, and directly opposite this, above the anal fin, are situated two large, nearly black ocelli, surrounded by a pinkish halo; at the base of the caudal fin are two similar, smaller ocelli.

Description. Body elongated. The greatest depth of the body, exclusive of the dorsal and anal fins, is just back of the posterior extremities of the pectorals. The length of the head is not quite equal to one fourth the length of the entire fish. The eyes are prominent, oblong, situated over each other, separated by a prominent, smooth, bony ridge; their longest diameter is about equal to one sixth the

length of the head. The upper jaw projects beyond the lower when the jaws are closed. The upper jaw has four or five prominent teeth in its front, and numerous card-like teeth towards its angles; in the lower jaw there are from seven to ten teeth on each side. The chin is prominent. The posterior nostril is the larger.

The lateral line curves over the pectorals to their posterior extremity, then pursues a strait course to the tail, and is lost on the central caudal ray.

The dorsal fin commences over the anterior superior angle of the eye, and its rays gradually become higher, until, having reached their highest point just back of the centre of the fin, they gradually diminish in height, and terminate rather abruptly at the fleshy portion of the caudal fin.

The moderate-sized pectorals are situated just beneath the posterior angle of the operculum.

The ventrals are small, broad, and stout.

The anal fin commences just back of the base of the pectorals, and terminates on a line with the termination of the dorsal fin.

The caudal fin is large and angulated, with stout rays.

The fin rays are as follows: — D. 86. P. 10. V. 6. A. 76. C. 17.

Length, twelve to sixteen inches.

Remarks. Captain Atwood informed me that he never noticed this species previous to the year 1846. During a visit to Long Point, Provincetown, in the latter part of June, 1847, I observed numerous specimens there. I have seen a single specimen having both sides dark-colored, — and both bearing the peculiarly marked ocelli, — with the exception of the head, which was, as usual, colorless beneath.

Massachusetts, Storer.

GENUS III. PLEURONECTES, Dekay. (RHOMBUS of Cuvier.)

Eyes and colored surface on the left. Teeth in the jaws and pharynx. Dorsal fin commences anterior to the eye.

Pleuronectes maculatus, *Mitchill.*

(Plate XXXI. Fig. 4.)

Pleuronectes maculatus, New York Plaice, Mitch., Report in part, p. 9.
Pleuronectes aquosus, Plaice of New York, Mitch., Trans. Lit. and Phil. Soc. of New York, I. p. 389, pl. 2, fig. 3.
Rhombus aquosus, Cuvier, Règne Animal.
Pleuronectes maculatus, Spotted Turbot, Dekay, Report, p. 301, pl. 47, fig. 151.
" " Storer, Mem. Amer. Acad., New Series, II. p. 479.
" " " Synopsis, p. 227.

Color. The living fish is of a greenish-brown color above, with small darker

green irregularly formed blotches, and dotted with a great number of minute white spots resembling snow-flakes, the spots near the back being the largest. The fins are of the color of the body. The rays of the pectoral fins are regularly spotted, and present the appearance of bands; their connecting membrane is perfectly colorless and transparent. The pupils are black, the irides golden.

Description. Body nearly orbicular, translucent. The scales are very small and round. The greatest depth of the body, exclusive of the fins, is rather less than half of its length. The length of the head is less than one fifth its entire length. The eyes are moderate in size: the inferior is anterior. The mouth is protractile; both of the jaws are furnished with a row of minute, sharp teeth; a patch of similar teeth are situated on the vomer. The nostrils are large, the anterior tubular: on the left, or colored side of the fish, the posterior nostril is just above the anterior angle of the inferior eye, and the anterior nostril is on a line before this. On the right, or colorless side, the nostrils are just below the origin of the dorsal fin.

The lateral line makes a high arch over the pectorals, whence it pursues a straight course to the caudal rays.

The dorsal fin commences on a line with the anterior nostril, above it, and is continued to the fleshy portion of the tail. The ten or twelve first rays of the dorsal fin are fleshy at their bases, and bifurcated just above their bases, and are again subdivided into delicate slips or filaments, which make them appear at first sight as if torn. The rays gradually become higher towards the centre of this fin, and again diminish as they approach the tail. This fin is rounded when expanded; the tips of the rays project just beyond the connecting membrane.

The pectorals are situated just beneath the posterior angle of the operculum; they are fan-shaped and transparent; their rays are bifid.

The ventrals arise at the angle of the lower jaw; the first ray is bifid, and its bifurcations are branched as in the first rays of the dorsal. The remaining rays are merely bifid at their tips.

The anus is situated at the posterior extremity of the ventrals.

The anal fin commences directly back of the anus. It is similar in its form to that of the dorsal, and is coterminal with that fin.

The caudal fin, which is rounded when expanded, is composed of strong, broad, bifid rays.

The fin rays are scaled, with the exception of the ventrals and the anterior rays of the dorsal and anal fins.

The fin rays are as follows: — D. 67. P. 10. V. 10. A. 51. C. $16\frac{2}{2}$.

Length, twelve to eighteen inches.

Remarks. When my "Report on the Fishes of Massachusetts" was published, I had never seen a specimen of this species. In August, 1845, Captain Atwood sent me a specimen from Provincetown; and in the following November I received one from the late Dr. Yale, from Holmes's Hole. While visiting Provincetown, in the summer of 1847, I saw this fish swimming about in considerable numbers, in shallow water, with the *Platessa oblonga* and *plana.* It is not used there as an article of food, although Dekay informs us that in New York it is considered a delicate fish.

Massachusetts, Storer. New York, Mitchill, Dekay.

GENUS IV. ACHIRUS, Lacepede.

Destitute of pectoral fins. Both eyes and color on the right side. Mouth distorted to the side opposite the eyes. Dorsal and anal extend to the tail, but are not united with it.

Achirus mollis, *Cuv.*

The New York Sole.

(Plate XXXII. Fig. 1. *b.* Left Side of Head.)

Pleuronectes mollis, New York Sole, Mitch., Trans. Lit. and Phil. Soc. of N. Y., I. p. 388, pl. 2, fig. 4.
Achirus mollis, Griffith's Cuv., x. p. 499.
" " Storer, Report, p. 149.
" " Dekay, Report, p. 303, pl. 49, fig. 159.
" " Storer, Mem. Amer. Acad., New Series, II. p. 480.
" " " Synopsis, p. 228.

Color. Upon the right side of a dark brown, marked transversely with rather indistinct, irregular, interrupted black bands; the left side is of a dirty white, with nearly circular dark brown blotches scattered over its entire surface, and also in a less marked manner upon the fins.

Description. Body oval. Length of the body, exclusive of the tail, four inches six lines; entire length, six inches; depth of the body two inches back of the snout, three inches, exclusive of the dorsal and anal fins. The length of the head is equal to nearly one fifth the length of the body. The eyes are small, circular, protuberant, and placed directly over each other. Directly in front of the upper eye, and in a line with it, just back of the commencement of the dorsal fin, almost entirely concealed, is a strong, compressed spine, two thirds of a line in length. The mouth is small, with minute teeth in both jaws on the under side; on the left side the aperture is partially concealed by the upper lip. The nostrils are large. The scales on

the body are quite small; on the lower anterior portion of the operculum, on the back just above the eyes, and on the fin-rays, they are larger. The left side is also scaly. The left side of the head is covered with soft filaments, which are continued along the base of the dorsal fin for an inch or more.

The lateral line commences just above the operculum, and is continued in a straight course to the base of the caudal rays.

The dorsal fin commences at the very anterior extremity of the back, which projects slightly beyond the upper jaw, and is continued to the tail, but not united to it.

The ventrals are situated just in front of the anal fin.

The anal fin commences in front of the posterior angle of the operculum, and terminates opposite the dorsal fin.

The caudal fin is nearly one third longer than its width at the base.

The rays of each fin are covered by scales on both sides.

The fin rays are as follows: — D. 55. V. 4. A. 38. C. 13. In a second specimen they were as follows: — D. 52. V. 4. A. 40. C. 16.

Length, six inches.

Remarks. Although Dr. Dekay speaks of this species as being common in the waters of New York, it must rarely be found in Massachusetts. In December, 1837, Dr. Yale, of Holmes's Hole, sent me a specimen which had been just taken in Tashmou Pond, about a mile from the village of Holmes's Hole. This pond is separated from the sea by a narrow beach, which is dry a portion of the year. Although Dr. Yale had resided many years at Holmes's Hole, and had a great fondness for natural history, he had never seen another specimen of this fish. In April, 1840, I received a specimen taken at Nahant. In January, 1847, Professor Agassiz procured two specimens in Boston market, which had been taken near Boston, in Charles River. Both Mitchill and Dekay consider this a very delicate fish for the table.

Massachusetts, north of Cape Cod, Storer. Nantucket to Carolina, Dekay.

FAMILY XX. CYCLOPTERIDÆ.

Ventrals suspended all around the pelvis, and united by a single membrane, forming an oval and concave disk, which the fish employs as a sucker to fix itself to the rocks. Mouth broad, furnished at the jaws and pharyngeals with small pointed teeth; opercula small. Branchial rays six. Pectorals very ample, and almost uniting under the throat, as it were to embrace the disk of the ventrals.

GENUS LUMPUS, Cuv.

Two dorsal fins; the first dorsal fin so enveloped by a thick and tubercular skin, that, externally, it might be taken for a simple hump of the back; second dorsal with branched rays, opposite the anal. Body deep and rough, with conical horny tubercles.

Lumpus Anglorum, *Willoughby*.

The Lump-Fish.

(Plate XXXII. Fig. 2.)

Cyclopterus lumpus, Lin., Syst. Nat., i. p. 414.
" " *Lump*, Bloch, iii. p. 92, pl. 90.
Lumpus Anglorum, Willoughby, p. 208, No. ii.
Cyclopterus lumpus, *Lump-Sucker*, Penn., Brit. Zoöl., iii. p. 176, pl. 24.
" " Shaw, Gen. Zoöl., v. p. 388, pl. 166.
" " *Common Lump-fish*, Jenyns, Brit. Vert., p. 471.
" " *Lump*, Rich., Faun. Boreal. Americ., iii. p. 260.
" " Fabricius, Faun. Grœnlandica, p. 131.
" " *Lump-Sucker*, Yarrell, Brit. Fishes, 2d edit., ii. p. 365, fig.
Cyclopterus cœruleus, *Blue Lump-fish*, Mitch., Trans. Lit and Phil. Soc. of N. Y., i. p 480, pl. 2, fig. 7.
Lumpus vulgaris, Cuv., Règne Animal, ii.
" " *Lump-Sucker*, Storer, Report, p. 151.
Lumpus Anglorum, *Lump-Sucker*, Dekay, Report, p. 305, pl. 54, fig. 175.
" " Storer, Mem. Amer. Acad., New Series, ii. p. 481.
" " " Synopsis, p. 229.

Color. All the upper part of the body is of a bluish-slate color; the sides and abdomen are of a yellowish-green. The immature fish is blue above, and almost entirely white beneath. Lips yellow.

Description. The body is suborbicular, compressed at its upper part. The entire surface of the fish is covered with an immense number of small stellated tubercles, studding, in the adults, even the rays of all the fins. Three rows of tubercles, much larger than those which are universally distributed over the fish, and terminating at their apices in naked spines, are observed projecting from either side. One row, commencing at the upper anterior angle of the eye, curves slightly over the humeral bones, and then passes in nearly a straight line to the tail; a second row, composed of much larger, wider, and more prominent tubercles, commences just beneath the posterior angle of the operculum, and terminates on the same plane with the extremity of the first row, the tubercles having diminished in size as they approached the tail, as in the first row; a third row, composed of a small number of still larger tubercles, commences on a line with the posterior portion of the ventral disk, and terminates just in front of the anal fin, forming the outer boundary of the abdomen. The two upper rows of tubercles are of the color of the back; the lower row is colored like

the abdomen. The tubercles of all these rows are granulated upon their sides, and have a naked spine at their summit. The greatest depth of the fish is equal to more than one half its length. The length of the head is less than one quarter the length of the fish. The head is covered with tubercles similar to those of the body; those on the posterior inferior angle of the operculum are larger than those on the other parts of the head. The eyes are circular; their diameter is equal to less than one third the distance between the eyes. The nostrils are large, tubular. The teeth are sharp and compact. A greater number of rows are in the upper than in the lower jaw; two small patches of minute teeth above and below in the pharynx. Just back of the top of the head, a compressed ridge rises abruptly and curves upward and backward to the posterior half of the body; its depth in the middle being equal to one third of its length; and its length equal to one third the length of the body of the fish. This ridge is formed of eight rays, which are perfectly distinct when the fish is dissected, and readily distinguished also in the dried specimen. The top of this ridge is covered with tubercles precisely similar to those which compose the middle row on the body; directly back of this dorsal ridge is a small flat surface composing the space between it and the dorsal fin, whose sides are armed with strong, prominent tubercles.

The dorsal fin, which is rounded, and one sixth longer than high, with rays multifid, is situated directly behind the flat surface just referred to.

The pectorals are longer at their base than the height of their highest rays; the height of the inferior rays is equal to about one fifth the height of the longest; these fins are rounded when expanded.

The ventrals, together with the anterior portion of the pectorals, form an oblong disk, of a bright yellow color, with six well-marked lines on each side of its centre, by which it is enabled to attach itself very powerfully to foreign substances.

The anal fin, commencing about on a line opposite the beginning of the dorsal, terminates on the same plane with that fin.

The caudal fin, when not expanded, is a little higher than wide; when expanded, it is one quarter wider than high. The depth of this fin at its base to its extremities when expanded is as two to five.

The fin rays are as follows: — D. 10. P. 20. A. 10. C. 12.

Length, eight to twenty inches.

Remarks. The whole appearance of this fish is very forbidding, being in young specimens a soft, gelatinous, tremulous mass; in older specimens it is of a much firmer consistence; but in both it is covered entirely with firm, horny spines.

This not uncommon species in Massachusetts Bay is frequently seen after severe storms thrown upon our beaches. Occasionally it is taken while fishing for cod, with the hook; and it is also caught in nets set for menhaden; generally, however, it is found attached to sea-weed and other substances floating near the shore.

Richardson tells us that "the Greenlanders eat its flesh, either cooked or dried, and its skin raw, throwing away only the tubercles"; and Dr. Neal observes, "that it is purchased at Edinburgh for the table." With us, however, it is not used as an article of food. The common weights of this fish are from three to four pounds, and from six to twelve pounds. The largest specimen I have met with was taken in January, 1843, and weighed eighteen pounds and three quarters.

Greenland, FABRICIUS. Maine, Massachusetts, STORER. New York, MITCHILL, DEKAY.

FAMILY XXI. ECHENEIDÆ.

With a flattened disk upon the top of the head, composed of numerous cartilaginous transverse plates, directed obliquely backwards, dentated or spinous at their posterior edge, and movable, by means of which they are enabled to attach themselves to other substances.

GENUS ECHENEIS, LIN.

Body elongated, covered with very small scales. A single dorsal fin, placed opposite the anal. Head very flat, covered with a disk; mouth wide, with numerous small, recurved teeth on both jaws, tongue, and vomer.

ECHENEIS ALBICAUDA, *Mitchill.*

The White-tailed Remora.

(PLATE XXXII. FIG. 3.)

Echeneis albicauda, White-tailed Remora, MITCHILL, Amer. Monthly Magazine, II. p. 244.
Echeneis naucrates, The Indian Remora, STORER, Report, p. 153.
Echeneis albicauda, White-tailed Remora, DEKAY, Report, p. 307, pl. 54, fig. 177.
" " " " STORER, Bost. Journ. Nat. Hist., IV. p. 183.
" " " " " Mem. Amer. Acad., New Series, II. p. 483.
" " " " " Synopsis, p. 231.

Color. Above, of a grayish-slate color; lighter upon the sides, with a dark band, which, commencing at the tip of the lower jaw as a small black point, runs along its margin to the angle of the jaw, where it expands to a band which passes to the tail, interrupted only by the eyes; in front of the pectorals this band is only two

lines in width, at the pectorals it grows wider, is widest beneath them, and becomes gradually smaller as it approaches the posterior extremity of the fish. The first ray of the dorsal fin is margined with white. The pectorals are the color of the body. The anal fin is dark-colored, edged with white. The upper and lower extremities of the caudal fin are white.

Description. Body cylindrical, elongated. The greatest depth of the body, exclusive of the fins, is equal to one tenth its length. The length of the head, from the tip of the lower jaw to the posterior angle of the operculum, is equal to about one seventh the entire length of the fish; the depth of the head at the posterior portion is equal to half of its length; its width over the same portion is equal to one third of its length. The top of the head is flattened; the body between the disk and the dorsal fin is nearly circular; back of the dorsal fin it is somewhat compressed. Upon the top of the head is an adhesive disk, about one fifth the length of the body, at its anterior extremity equal in width to about one third the length of the head; the widest part of the posterior extremity is slightly greater. This disk extends from the tip of the upper jaw to the middle of the pectorals; it has twenty-one light-colored transverse plates, divided by a longitudinal median fleshy line; the entire disk is margined by a fleshy border from one to four lines wide. The eyes are situated half-way between the tip of the lower jaw and the extremity of the operculum; they are circular, and between three and four lines in diameter. The nostrils are double, with fleshy appendages. The jaws are crowded with numerous small, card-like teeth. Teeth also are observed in the throat and upon the palatine bones. The lower jaw terminates in a point in advance of the upper.

The dorsal fin arises just anterior to the middle of the body. It is rather more than one third the length of the fish. It is of a dark slate color; the tips of the anterior rays are edged with white.

The pectorals commence on a line with the posterior fifth of the disk; their depth to their length is as one to three.

The ventrals are situated just posterior to the pectorals; their depth is equal to one sixth their length.

The anal fin arises directly opposite, and terminates upon the same plane as the dorsal. Its anterior rays are higher than those of that fin. The anus is half an inch in front of this fin.

The caudal fin is nearly even at its extremity.

The fin rays are as follows: — D. 29. P. 18. V. 5. A. 30. C. 18.

Length, twenty inches.

Remarks. This species is exceedingly rare in our waters; the specimen from which my description was drawn up, in my "Report on the Fishes of Massachusetts," was taken from the bottom of a fishing-smack, to which it was attached, in Boston Bay.

Massachusetts, STORER. New York, MITCHILL, DEKAY.

ECHENEIS QUATUORDECIMLAMINATUS, *Storer.*

The Fourteen-plated Remora.

(PLATE XXXII. FIG. 4.)

Echeneis quatuordecimlaminatus, Fourteen-plated Remora, STORER, Report, p. 155.
" " " " an juv.? DEKAY, Report, p. 309.
" " STORER, Mem. Amer. Acad., New Series, II. p. 484.
" " " Synopsis, p. 232.

Color. Of a light reddish-brown color, rather darker beneath. The pectoral and ventral fins are a little lighter than the body. The dorsal and anal fins are clouded with a lighter tint.

Description. Body fusiform, elongated. The length of the head is less than one fifth the length of the entire fish: above, it is entirely covered by an adhesive disk, which commences at the tip of the upper jaw, and, extending on each side to the eyes, terminates on a plane with the posterior half of the pectorals: this disk is surrounded by a fleshy margin, which is tipped with a darker brown than the color of the body, and is divided in its centre by a longitudinal fleshy septum, on each side of which are fourteen or fifteen distinct, strongly serrated laminæ. The gill-covers are large; the lower jaw projects beyond the upper; the jaws are armed with several rows of strong, sharp, recurved teeth; teeth also are observed upon the pharynx, the palatine bones, and the root of the tongue. The gape of the mouth is moderate in size. The eyes are horizontally oval. The nostrils, which are near the edge of the upper jaw, are double.

The lateral line commences at the origin of the pectorals above, and, making a slight curve from their extremities, is continued in a straight course to the tail.

The dorsal fin commences about the middle of the length of the fish: it is rounded anteriorly, gradually diminishes in height as it approaches the tail, and terminates posteriorly above in a point.

The pectorals are somewhat rounded at their extremities.

The ventrals are narrow and triangular; and are attached to the belly by a membrane extending from the inner ray; the rays are multifid.

The anal fin commences a short distance back of the dorsal, is of a form somewhat similar to that fin, and terminates upon the same plane with it.

The caudal fin, composed of stout fleshy rays, is nearly straight at its posterior extremity. The distance between the extremities of the outer rays is equal to the height of those rays.

The fin rays are as follows: — D. 32. P. 22-24. V. 5. A. 28-30. C. 18.

Length, seven and a half inches.

Remarks. This may be an immature fish which I have described; but I think it must be a new species. According to Dekay, three species of Remora are observed upon the coast of New York, the Albicauda, Naucrates, and Remora. I think it cannot be one of these species. It has not the broad longitudinal band, nor the white tips at the extremities of the caudal fin, noticed in the Albicauda, nor has it the twenty or twenty-three plates observed in the disk of that species. From the Naucrates it differs in its color, and the number of plates in the disk.

In the Remora the disk extends to the end of the pectorals; in this species it terminates at the commencement of the posterior half of these fins. In this species the dorsal and anal fins are not coequal; the dorsal fin of the Remora has twenty-one rays, while in this species it has thirty-two; the anal fin in the Remora contains twenty rays, the same fin in this species has twenty-eight rays. The caudal fin of the Remora is crescent-shaped.

I have seen but two specimens of this species. One of these was received from the late Dr. Yale, of Holmes's Hole, and served for the description contained in my "Report." The other was taken at Wellfleet, in August, 1844. One of these measured five inches and a half, and the other seven inches and a half.

APODES.

No ventral fins.

FAMILY XXII. ANGUILLIDÆ.

Body very much elongated and cylindrical, for the most part of a serpentine figure. Scales scarcely apparent, being imbedded in a soft and thick skin. Air-bladder of various singular forms. No cœcal appendages.

GENUS I. ANGUILLA, Cuv.

The dorsal commencing considerably behind the pectorals, and uniting with the anal to form the caudal. Lower jaw the longer. Mouth with a row of teeth in each jaw, and a few on the anterior part of the vomer.

Anguilla Bostoniensis, *Dekay.*

The Common Eel of Massachusetts.

(Plate XXXIII. Fig. 1.)

Anguilla vulgaris, Common Eel, Mitch., Trans. Lit. and Phil. Soc. of N. Y., i. p. 360.
" " *Fresh-water Eel,* Mitch., Amer. Month. Mag., ii. p. 242.
Muræna Bostoniensis, Lesueur, Journ. Acad. Nat. Scien., i. p. 81.
" " *Common Eel of Massachusetts,* Storer, Report, p. 158.
Anguilla tenuirostris, Common Eel of New York, Dekay, Report, p. 310, pl. 53, fig. 173.
Anguilla Bostoniensis (Lesueur), Dekay, Report, p. 313.
" " Ayres, Bost. Journ. Nat. Hist., iv. p. 279.
" " Storer, Mem. Amer. Acad., New Series, ii. p. 485.
" " " Synopsis, p. 233.

Color. This species is of a greenish or olive-brown above, and yellowish or yellowish-white beneath; frequently a reddish tinge is noticed along the margin of the anal fin. In the smaller specimens, the opercula, throat, and abdomen anterior to the vent, are of a bluish slate color, with scarcely a tint of yellow. The dorsal fin is of the same color as the back.

Description. Body cylindrical, compressed posteriorly, terminating in a point. The head is equal to about one tenth the length of the body, compressed above, tapering to a blunt point at the snout; the distance across the occiput is equal to about half the length of the head. The lower jaw slightly projects; both jaws are furnished with several rows of small, incurved, card-like teeth. The lips are fleshy. The vertical gape of the mouth is equal to half the length of the head. The eyes, situated just above and anterior to the angle of the jaw, are equal to one eighth the length of the head. The posterior nostrils, which are oval, are situated directly in advance of the superior anterior angle of the eye. A small tubular cirrhus projects forwards from the anterior nostrils situated on each side of the snout. A line of mucous pores are observed between the anterior and posterior nostrils, and another series pass backwards to the posterior inferior angle of the eye.

The lateral line commences above and in front of the pectoral fin, and pursues a straight course to the very extremity of the fleshy portion of the tail.

The dorsal fin arises on the anterior half of the body, and is continued to the

caudal fin, which is again connected with the anal; the three forming one continuous fin. The widest portions of these fins are at a short distance in front of their posterior termination. The number of rays in these united fins is about four hundred and fifty-five.

The anus is small, and situated just anterior to the anal fin.

The pectorals are directly back of the branchial aperture; they are somewhat rounded at their extremities, and are composed of sixteen rays.

Length, twenty-four to thirty-four inches.

Remarks. Dr. Mitchill, in his paper on the "Fishes of New York," published in 1815, briefly refers to this species, which he incorrectly considered the *Anguilla vulgaris*, Bloch. Lesueur, in the first volume of the "Journal of the Academy of Natural Sciences of Philadelphia," published in 1817, describes it as a new species, with sufficient accuracy to be readily distinguished, under the name of *Muræna Bostoniensis.* Subsequently, in February, 1818, Dr. Mitchill minutely and clearly described it as the *Anguilla vulgaris.* In my "Report on the Fishes of Massachusetts," I included it under the name given it by him who first knew it to be, and described it as, a new species. Dr. Dekay has since called it *Anguilla tenuirostris.*

In my "Report," &c., I included a species which I supposed to be the *argentea* of Lesueur. This was also contained in my "Synopsis of the Fishes of North America." In October, 1845, my friend, the late Dr. Yale, sent me a living specimen of this fish from Holmes's Hole, where it is called the Neshaw eel. I carefully compared this specimen with the *A. Bostoniensis*, and could not perceive characteristics sufficiently well marked to make them distinct species. The color of the Neshaw eel is rather more of a brown than greenish, and the abdomen is destitute of the yellowish tinge possessed in the common specimens in the market; but these differences may be dependent upon its locality. Dr. Yale writes: "The Neshaw eel is taken in all the ponds and lagoons connected with the sea on the Vineyard; and are taken in October and November in pots while making their way from the ponds to the sea. It is said, that, when the openings from the ponds are closed, they pass over the sand in the night."

The common eel of Massachusetts is taken along our entire coast, as well as in the rivers and ponds of the State. At some seasons, spring and winter, for instance, great numbers are brought to market from the mouths of the neighboring rivers, upon the muddy bottoms of which they live. They meet with a ready sale. So great is the demand sometimes that it cannot be answered. During the winter this species is speared, holes being cut through the ice for this purpose. In spring the

markets are usually supplied from the rivers, where they are taken in nets. At Medford nets are stretched across the river, having in their middle a large bag capable of containing from fifteen to twenty bushels; as the eels are going up or down the river they are caught, and are kept alive for the supply of the market in large ditches, excavated near the river, which are supplied by the tide-water. About three thousand pounds are yearly taken at Watertown. Those taken in summer, when they are able to procure the britt, and other fishes upon which they feed, are much the larger and richer, weighing from one to nine pounds. In October, 1844, I saw an individual measuring two feet and ten inches in length, and weighing three pounds and a half, which was taken in Medford River, which agreed in its measurements with the one I have above described, and was, I suppose, a mere variety, although it was of a dark olive-brown above, and of a slate color beneath, without the slightest tint of yellow, and a very slight tinge of red along the anal fin. The fishermen suppose this peculiarity of color, which it appears they occasionally see, is owing to their being confined entirely to fresh water, and never having visited the sea.

Massachusetts, Lesueur, Storer. Connecticut, Linsley. New York, Mitchill, Dekay.

GENUS II. AMMODYTES, Linn.

Head and body elongated; gill-openings large; dorsal fin extending nearly the whole length of the back; anal fin of considerable length; dorsal and anal fins separated from the caudal fin. Lower jaw longest. Their stomach is pointed and fleshy; they have neither cœca nor natatory bladder.

Ammodytes Americanus, *Dekay.*

Sand-Eel.

(Plate XXXIII. Fig. 2.)

Ammodytes tobianus, Sand-Launce, Bloch, Mitch., Trans. Lit. and Phil. Soc. of N. Y., i. p. 363.
" " *Sand-Eel,* Storer, Report, p. 159.
Ammodytes Americanus, American Sand-Launce, Dekay, Report, p. 317, pl. 52, fig. 167.
Ammodytes lancea, Ayres, Bost. Journ. Nat. Hist., iv. p. 280.
Ammodytes tobianus, Little Sand-Eel, Linsley, Cat. of Fishes of Connecticut.
Ammodytes lancea, Banded Sand-Launce, " " "
Ammodytes Americanus, Storer, Mem. Amer. Acad., New Series, ii. p. 489.
" " " Synopsis, p. 237.

Color. Of a dirty greenish-brown color upon the back; the sides and abdomen are silvery; the top of the head is flesh-colored; the preopercles are silvery; the opercula are cupreous and silvery. The pupils are black, the irides silvery.

Description. Body elongated, slightly compressed. Head pointed at snout. The length of the head, from the extremity of the snout to the end of the gill-covers, is more than one fifth the length of the entire fish. The lower jaw projects beyond the upper, and terminates in a conical tip. From the anterior inferior portion of the operculum, a few slight striæ pass obliquely upwards, backwards, and downwards to its posterior margin. The nostrils are double, and are situated half-way between the eyes and the snout. The eyes are circular; the diameter of the eye is equal to one ninth the length of the head.

The lateral line is straight and indented.

The very delicate dorsal fin commences on a line with the end of the pectorals, and terminates at the fleshy base of the caudal fin. This fin is rather highest just posterior to its centre. When unexpanded, it is received into a groove at its base.

The pectorals are one third the length of the head. From their base a slight membrane extends posteriorly on each side of the abdomen.

The anal fin, which is about as high as the dorsal fin and terminates posteriorly on a line with it, is just one third the length of the entire body.

The caudal fin is forked.

The fin rays are as follows: — D. 61. P. 13. A. 28. C. 14.

Length, six to twelve inches.

Remarks. This species, which is generally known among fishermen as the "Sand-Eel," is found plentifully at Holmes's Hole, and it oftentimes collects at Provincetown in myriads. In June, 1847, while on a visit at this latter place, I observed the shores were lined with these fishes, which were left by the refluent tide. Captain Atwood assured me that the waters around Longpoint were at times so densely crowded with them, as to seem literally alive. In a letter to me, dated June 18th, 1847, he says, while speaking of this species: "Last Friday night they ran ashore in such quantities, that they covered the ground from one to two inches deep, and when the water covered the flats the whole bottom looked like an immense sheet of silver."

When thus situated they are readily devoured by their enemies, among whom are the cuttle-fish.

Banks of Newfoundland, H. R. Storer. Massachusetts, Storer. Connecticut, Ayres, Linsley. New York, Mitchill, Dekay.

LOPHOBRANCHII.

Gills, instead of being, as usual, pectiniform, are divided into little round tufts, dispersed in pairs along the branchial arches.

FAMILY XXIII. SYNGNATHIDÆ.

Body mailed with transverse angular plates. Opercle large; branchial opening very small, and formed by a membrane which only exhibits vestiges of rays. Dorsal single. No cœca; with an air-bladder.

GENUS I. SYNGNATHUS, Linn.

Body elongated, slender, covered with a series of indurated plates, arranged in parallel lines; head long; both jaws produced, united, tubular; no ventral fins. Males with a pouch for the reception of the female roe.

Syngnathus Peckianus, *Storer.*

Peck's Pipe-fish.

(Plate XXXIII. Fig. 3.)

Syngnathus typhle, Smaller Pipe-fish, Mitchill, Trans. Lit. and Phil. Soc. of N. Y., i. p. 475.
Syngnathus Peckianus, Peck's Pipe-fish, Storer, Report, p. 163.
Syngnathus fuscus, Brown Pipe-fish, Storer, Report, p. 162.
Syngnathus fasciatus, Banded Pipe-fish, Dekay, Report, p. 319, pl. 54, fig. 174.
Syngnathus viridescens, Green Pipe-fish, Dekay, Report, p. 321, pl. 54, fig. 176.
Syngnathus fuscus, Dekay, Report, p. 321.
Syngnathus Peckianus (Storer), Dekay, Report, p. 321.
" " Ayres, Bost. Journ. Nat. Hist., iv. p. 282.
" " Storer, Mem. Amer. Acad., New Series, ii. p. 490.
" " " Synopsis, p. 238.

Color. A living male specimen presents the following appearances. Of a greenish-brown color above, with several irregular transverse broad dark bands; numerous narrower bands upon the sides of the same color. The upper portion of the operculum is olive-colored; the lower portion is of a golden yellow. The abdomen in front of the anus is golden; the portion just back of the anus is very broad, and contains a flesh-colored membrane, which separates in its centre, forming two flaps; the lower portion of the sides, exterior to this dilated part, is sprinkled with minute white dots; and along this outer edge is a beautiful deep-brown band,

extending its whole length. The inferior portion of the body posterior to the membranous flap is of a pinkish hue. The throat is of a bright yellow color. The pupils of the eyes are black; the irides are coppery. A yellowish-brown band passes downwards and backwards from the posterior angle of the eye to the centre of the operculum. Along the outer edge of the rostrum, from the eye almost to the snout, passes a dark-brown band. The dorsal fin is transparent, and indistinctly longitudinally banded with brown. The pectorals and anal fin are colorless. The caudal fin is wholly brown.

When the fish is preserved in spirits, the colors almost entirely disappear; the band on the outer edge of the abdominal flaps, the transverse bands on the back and sides, and the bands on the rostrum, are scarcely, if at all, perceptible; and the flesh-colored membrane of the pouches becomes of a dull white color.

Description. Body elongated, compressed upon the sides, flattened above, and gradually tapering from the head to the tail; its whole surface being covered with horny, striated plates. The depth of the body just back of the pectorals, and also at the anus across, equal to one thirty-sixth its entire length; the width of the body at the anus is equal to half the depth back of the pectorals; the width at the centre of the pouches is equal to the depth back of the pectorals; the length of the pouches is less than one third the length of the fish.

The length of the head, from the extremity of the snout to the posterior angle of the operculum, is equal to one ninth the entire length of the fish. Rostrum tubular, compressed. The lower jaw is rather the longer, and passes obliquely upwards to form the mouth. The eyes are prominent, and very movable in their orbits. The orbitar edges being elevated, a depression is seen between the eyes; in the centre of this depression arises a slight ridge, which is continued upon the top of the rostrum to the tip of the snout; upon the top of the head is situated another ridge which is continued on the neck posterior to the origin of the pectorals. The opercula are pectinated; or of the form of a Pinna, broad posteriorly, rounded beneath and behind, and covered with striæ radiating from their circumference.

The anterior portion of the body is heptangular: on each side of this portion are three ridges, and one upon the abdomen. One of these ridges commences at the posterior superior angle of the operculum, and is continued in a straight line nearly to the termination of the dorsal fin; this ridge forms the lateral boundary of the dorsum.

The second ridge arises beneath the pectorals at their base, and, passing along

the middle of the side of the fish, terminates beneath the centre of the dorsal fin, above the anus.

The third ridge commences below and anterior to the pectoral fins, and, bounding the sides of the abdomen, is continued to the tail. Besides these three ridges on each side, a seventh ridge, commencing at the throat, passes through the centre of the abdomen to the vent. Just above the termination of the second ridge, or that upon the centre of the sides, another ridge commences, which passes backwards to the termination of the first ridge, or that upon the side of the back, then, curving upwards to the sides of the back, takes the place of the first ridge, and is continued to the tail. Back of the vent the abdominal ridge disappears, so that the space between the vent and the termination of the first ridge is hexangular. Back of the dorsal fin, the ridge upon the centre of the sides having disappeared, the body is quadrangular.

In front of the anus are nineteen transverse plates, and in front of the dorsal fin are fourteen of these plates; between the anus and the caudal fin are forty-two of these plates. The portion of the abdomen just back of the vent is much wider than the rest of the body, and presents the membranous flaps, which approach each other at the median line, thus forming pouches or a false belly in which are contained the ova of the female.

The dorsal fin is situated at the commencement of the second third of the body, or at a distance back of the tip of the snout equal to one third the entire length. It is slightly rounded above, and is longer than the head; the height of its rays is equal to about one fifth the length of the head.

The anus is situated directly beneath the middle of the dorsal fin.

The pectorals are rather small, and are rounded when expanded.

The anal fin is exceedingly delicate, scarcely discernible without the aid of a glass.

The caudal fin is fan-shaped when expanded; the extremities of the rays project slightly beyond the connecting membrane.

The fin rays are as follows:— D. 45. P. 14. A. 3. C. 12.

Length, six to twelve inches.

Remarks. This species is frequently taken in nets, in the waters of Boston Harbor, by boys, while catching minnows for bait. Its motions are exceedingly rapid, resembling the gyrations of the Colubridæ. In one of the specimens described in my Report, numerous ova contained in its false pouches were hatched soon after it was taken, and when I received it, two days subsequent to its capture, it was

surrounded by one hundred and fifty young, about half an inch long, which, with the exception of several narrow transverse black bands, were nearly colorless. In several others, examined at the same time, their pouches were crowded with ova, or in the act of protruding the young.

The following remarks accompanying my original description of this species may not be considered inappropiate here.

Among the earliest cultivators of Ichthyology in our country no name is more prominent than that of William Dandridge Peck. So early as the year 1794, while residing at the town of Kittery, in Maine, he wrote a clear and accurate "description of four remarkable fishes, taken near the Piscataqua, in New Hampshire." This paper was published in 1804, in the second part of the second volume of the "Memoirs of the American Academy of Arts and Sciences," accompanied with very good figures, when the early period of our country is considered. The manuscript of his Ichthyological Lectures also, afterward delivered by him at Harvard University as Professor of Natural History, and kindly loaned me to examine by my friend Thaddeus William Harris, M. D., Librarian to the University, exhibit no inconsiderable degree of research. As the species described and first published by him as new have, *three of them at least*, been described by other naturalists under other specific names, I feel that I am performing an appropriate duty in connecting the name of our deceased countryman, whose merits have been unjustifiably overlooked, with one of a class of animals whose history he so successfully endeavored to elucidate.

Massachusetts, STORER. Connecticut, LINSLEY. New York, MITCHILL, DEKAY.

GENUS II. HIPPOCAMPUS, CUV.

The jaws united and tubular, like those of the Syngnathi; mouth placed at the end; body compressed, short, and deep; the whole length of the body and tail divided by longitudinal and transverse ridges, with tubercular points at the angles of intersection; pectoral and dorsal fins; no ventral nor caudal fins; the females only have an anal.

HIPPOCAMPUS HUDSONIUS, *Dekay*.

Short-nosed Sea-Horse.

(PLATE XXXIII. FIG. 4.)

Syngnathus hippocampus, Sea-Horse Pipe-fish, MITCH., Trans. Lit. and Phil. Soc. of N. Y., I. p. 475.
Hippocampus brevirostris, Short-nosed Sea-Horse, STORER, Report, p. 167.
Hippocampus Hudsonius, Hudson River Sea-Horse, DEKAY, Report, p. 322, pl. 53, fig. 171.
Hippocampus brevirostris, LINSLEY, Cat. of Fishes of Connecticut.
Hippocampus Hudsonius, STORER, Mem. Amer. Acad., New Series, II. p. 491.
" " " Synopsis, p. 239.

Color. Yellowish-brown throughout.

Description. Body heptagonal, composed of twelve segments, which are armed on each side with three rows of prominent spines, and a single row of similar spines are noticed beneath. The greatest depth of the body is across from the dorsal fin. The length of the head is more than one fifth the entire length of the fish. The head is compressed upon the opercula and surmounted above by a bony prominence which expands into five points, four lateral and one posterior. Behind this are situated the branchial orifices. A short spine is seen at the base of the snout, in front of the eyes; on each side of this is a minute spine; directly above each eye is a larger spine; and at the posterior angle of the eye is a very short one: beneath the eye, on the throat, are two small ones on each side. The snout is straight and tubular, and measures ten lines to the anterior base of the opercula. The eyes are large. The tail is quadrangular, about half of its entire length; it is divided into thirty-four segments, and gradually terminates in a point.

The dorsal fin is situated upon a slight projection of the dorsum, composed of three segments, at the origin of the tail.

The fin rays, as well as can be determined with the specimen much contracted and otherwise injured by drying, are as follows: — D. 18 or 20. P. 14 or 15. A. 3 or 4.

Length, five inches.

Remarks. In my "Report" I described this species from the only specimen I had seen. It was found by Dr. Yale upon the shore at Holmes's Hole, and was sent by him to the cabinet of the Boston Society of Natural History. He observed, in a letter to me, "he never knew one to be taken alive, yet they are frequently found on the shore." The specimen described was a female. As I have seen no specimen since that was noticed, I can only redescribe it, and accompany the description with a figure, which, considering the dried condition of the fish, is quite accurate.

I was undoubtedly in error in considering this species as the *brevirostris*, and with pleasure adopt the specific name of my lamented friend, Dr. Dekay.

Massachusetts, STORER. Connecticut, LINSLEY. New York, MITCHILL, DEKAY.

PLECTOGNATHI.

The maxillary bone soldered or fixedly attached on the side of the intermaxillary, which alone forms the jaw, and to which the palatine arch is dovetailed by a suture within the cranium, and consequently has no power of motion. Opercula and the rays concealed under a thick skin, which only permits a small branchial cleft to be visible externally.

FAMILY XXIV. GYMNODONTIDÆ.

Instead of apparent teeth, the jaws are furnished with an ivory substance, divided internally into laminæ, the general appearance of which somewhat resembles the bill of a parrot, and which is essentially composed of true teeth united together, and succeeding one another in proportion as there are any worn out by trituration. Opercula small; their rays five in number.

GENUS I. TETRODON, Linn.

Jaws divided in the middle by a suture, presenting the appearance of four teeth in front, two above and two below. The skin over a portion of its whole extent covered with prickles.

Tetrodon turgidus, *Mitchill.*

The Swell-fish. Puffer.

(Plate XXXIII. Fig. 5. *b.* Jaws.)

Tetraodon turgidus, *Puffer*, Mitch., Trans. Lit. and Phil. Soc. of N. Y., i. p. 473, pl. 6, fig. 5.
" " *Swell-fish*, *Puffer*, Storer, Report, p. 169.
" " *Common Puffer*, Dekay, Report, p. 327, pl. 55, fig. 178.
" " " Ayers, Bost. Soc. Nat. Hist., iv. p. 285.
" " " Storer, Mem. Amer. Acad., New Series, ii. p. 493.
" " " " Synopsis, p. 241.

Color. Upper part of the body ash-colored, interspersed with light pea-green, with large irregular patches of greenish-brown. Sides orange, with a shade of brown, barred transversely by seven or eight blackish irregularly defined bands. Abdomen yellowish-white. Head greenish-brown. Pupils green, irides orange. Fins color of abdomen.

Description. Body oblong, cylindrical, globular when inflated. The whole surface

of the body, save the chin and the space between the dorsal and the caudal fins, and the anal and caudal, roughened by innumerable small spines. The greatest depth of the body when collapsed is one fourth the length of the body; when inflated, its greatest depth is one third the length of the body; the greatest width of the fish is equal to one third its length. The length of the head is nearly one third the length of the body. The eyes are large, and horizontally oval. The distance between the eyes is equal to their longest diameter. The nostrils are situated just in front of the eyes, and are furnished with a fleshy filament. The jaws are stout and equal.

No lateral line is observable.

The fan-shaped dorsal fin arises just in advance of the anal fin. The first ray is the shortest, the third ray the longest of the fin.

The pectorals are subquadrangular.

The anal fin is rather smaller than the dorsal.

The caudal fin is nearly even at its extremity.

The fin rays are as follows: — D. 6 – 8. P. 15. A. 6, 7, 8. C. 6, 7.

Length, six to fourteen inches.

Remarks. This species is known by the names of Swell-fish, Bellows-fish, and Puffer, from its power of inflating itself with air. It is found along our entire coast. It is common at Nahant, and is sometimes taken from the bridges leading from Boston. At Manimsha Creek, in Chilmark, it exists in great numbers. When taken with the hook it is collapsed, but almost immediately inflates itself: this inflation is readily induced by scratching its abdomen.

Massachusetts, STORER. Connecticut, LINSLEY, AYRES. New York, MITCHILL, DEKAY.

TETRODON LÆVIGATUS, *Linn.*

The Smooth Puffer.

(PLATE XXXIV. FIG. 1.)

Tetraodon lævigatus, LIN., Syst. Nat., p. 411.
" " SHAW, Gen. Zoöl., v. p. 446.
Tamboril, PARRA, p. 37, pl. 19.
Tetraodon lævigatus, *Brown Globe-Fish*, MITCH., Report on the Fishes of New York, p. 28.
Tetraodon mathematicus, *Mathematical Tetraodon*, MITCH., Trans. Lit. and Phil. Soc. of New York, I. p. 474, pl. 6, fig. 6.
" " " " STORER, Supplement to Rep. Bost. Journ. Nat. Hist., IV. p. 183.
Tetraodon lævigatus, *Lineated Puffer*, DEKAY, Report, p. 329, pl. 56, fig. 182.
" " " " STORER, Mem. Amer. Acad., New Series, II. p. 493.
" " " " " Synopsis, p. 241.

Color. Of a deep olive-green color above; the sides are silvery; the inferior portion of the body is white. Pupils black, irides golden.

Description. Body elongated; anterior portion of the body much the more prominent; abdomen pendulous. The entire surface of the body is perfectly smooth, except the portion below the pectoral fins, posterior to the throat, and anterior to the anus, which is armed with an immense number of small stellated spines.

Several well-marked series of mucous pores are distributed over the surface, which have caused it to receive its common names, in the works of ichthyologists, of *lineated* and *mathematical.* One of these commences about half an inch back of the angle of the jaws; this passes backwards to the posterior extremity of the eye, being a short distance beneath the eye, then ascends obliquely to a point upon the back two inches above the middle of the pectoral fin, then curves downwards to the middle of the side of the fish, to a point about an inch back of the dorsal fin, whence it proceeds in a straight course to the caudal rays. This line from its origin also passes upward and backwards, just exterior to the nostrils, and, curving high up over the eyes, passes back of them and downward to meet the former line about half an inch back of the eyes, thus forming a ring around them. Directly above the base of the pectoral fins, a transverse line crosses from the lateral line on one side to that on the other. From this transverse line, an undulating line passes to the ring around the eyes.

Its greatest depth is less than one sixth its length. Its greatest width is across the base of the pectorals.

The length of the head is equal to about one quarter its entire length. The eyes are oblong. The nostrils are situated a short distance in front of, and rather above, the anterior angle of the eyes. The jaws are very strong. The lips are fleshy and lax.

The trapezoidal dorsal fin is situated upon the posterior half of the body.

The pectoral fins are short and subquadrangular.

The anal fin, of the same form and size of the dorsal, is directly opposite that fin.

The caudal fin is deeply forked.

The fin rays are as follows: — D. 13. P. 16. A. 12. C. 11.

Length, one to two feet.

Remarks. The only individual of this species I have seen was taken several years since at Nantucket, and was described by me, from the preserved specimen, in the Boston Journal of Natural History, 1843 – 4.

Massachusetts, STORER. New York, MITCHILL, DEKAY. South Carolina, LINN. Gulf of Mexico, PARRA.

GENUS II. ORTHAGORISCUS, Schn.

Jaws undivided, forming a cutting edge. Body compressed, without spines, not susceptible of inflation, and with the tail so short, and so high, vertically, that they have the appearance of fishes from which the posterior part has been cut away. Dorsal and anal, each high and pointed, united to the caudal. No natatory bladder; stomach small, and immediately receiving the biliary canal.

Orthagoriscus mola, *Schn.*

The Sun-fish.

(Plate XXXIV. Fig. 2.)

Tetraodon mola, Lin., Syst Nat. p. 412.
" " *Short Tetraodon*, Penn., Brit. Zoöl., iii. p. 172, pl. 22.
Diodon mola, Bloch, pl. 128.
Cephalis brevis, Short Sun-fish, Shaw, Gen. Zoöl., v. p. 437, pl. 175.
" " " Mitch., Trans. Lit and Phil. Soc. of N. Y., i. p. 471.
Orthagoriscus mola, Short Sun-fish (Schneider), Jenyns, Brit. Vert., p. 490.
" " Griffith's Cuv., x. p. 569.
" " *Short Sun-fish*, Yarrell, Brit. Fishes, 2d edit., ii. p. 462, fig.
" " Storer, Report, p. 170, pl. 3, fig. 1.
" " *Short Head-fish*, Dekay, Report, p. 331, pl. 59, fig. 193.
" " Storer, Mem. Amer. Acad., New Series, ii. p. 494.
" " " Synopsis, p. 242.

Color. The back is of a dark gray color; the sides of a grayish-brown, with silvery reflections; the abdomen is of a dull, dirty white. A broad, nearly black, band commences at the origin of the dorsal fin, and, running along its base, is continued, in front of the caudal and anal fins, to the anus; this band is lighter-colored along the base of the anal fin, and here it is also narrower, being about the same depth as at the dorsal; but along the base of the caudal it is considerably deeper. Pupils black, irides of a dark brown, encircled within by a silvery ring. The general color of the caudal fin is similar to that of the inferior portion of the sides; its outer edge is flesh-colored.

Description. Body oblong, compressed. Its entire surface presents a fine, unyielding granulated surface. The depth of the body across, from the middle of the pectorals, is equal to rather more than half its length; from the tip of the dorsal to the extremity of the anal, measured across the body, the distance is equal to about the length of the fish. The length of the head, from the tip of the snout to the base of the pectoral fin, is equal to one fifth the entire length; the head is flattened over the snout, which is obtuse and projecting. Upon the top of the

head an arched ridge commences on a line with the anterior angle of the eye, and is continued to a line above the origin of the pectorals; thence a straight line is pursued to the dorsal fin. The sides of the head project out from the body,— quite prominently over the eyes to the branchial aperture. The eyes are oblong, small, convex, very movable in their orbits; their larger diameter is one fourth greater than their smaller. The nostrils are double, very small, situated just in front of the eyes. The mouth is small. The jaws are armed with a broad bony plate, much worn in front, sharp at its edges. The temporal orifice is oval, and situated just in front of the pectoral fin.

The dorsal and anal fins are triangular, and situated at the upper and lower posterior extremities of the fish; the former slightly the posterior. These fins are almost precisely equal in their length and height.

The caudal fin borders the posterior extremity of the body, and reaches nearly to the base of the dorsal and anal fins, although it is not really connected with them. This fin is scalloped, or divided into digitations, about eight in number, the fourth of which is the longest. The digitations in the specimen here described are much more unequal than in that mentioned in my "Report."

The pectorals are one third the height of the dorsal fin; their length is equal to more than one third their height.

The anus is large and corrugated, and situated a short distance in front of the anal fin. Directly in front of the anus commences a very obvious carina, which is continued to a line opposite the origin of the pectorals. The very dense texture of these fins renders it about impossible to determine with accuracy the number of their rays. As nearly as I have been able to distinguish, they are as follows:— D. 13. P. 12. A. 13. C. 8–9.

Length, five to six feet.

Remarks. Three specimens of this fish, carefully examined, present the following proportions.

One, described in my "Report," measured fifty-four inches in length; depth across from the middle of the pectorals, two and a half feet; from the top of the dorsal to the extremity of the anal fin, six and a half feet. Weight, two hundred pounds.

A second, seen by Dr. Jeffries Wyman, also noticed in my "Report," measured fifty-four inches in length; diameter of the operculum, three inches; of the eye, two inches; greatest breadth of the fish, thirty inches; pectoral fins, eight inches high, six long, composed of ten rays; anal fin, eighteen inches high, ten long, composed of eighteen rays; nine scallops to the tail, six in the broadest part.

The individual now described measured fifty-four inches in length, and was judged to weigh nearly five hundred pounds.

This species is occasionally met with during the summer season in Massachusetts Bay, sluggishly swimming near the surface. On account of the great elasticity of its exterior, it is captured with difficulty, by being gaffed at or near the branchial aperture. Dr. Yale, writing of this species to me, observes: "It has an entire cartilaginous case of an inch and a half to two inches thick, covering the whole body, perfectly white and milky in its appearance, and very elastic. A small ball of it, cut out and thrown with moderate force upon the ground, will rebound from fifteen to twenty feet." Its liver, which weighs eight or ten pounds, is very oily, furnishing two or more quarts of oil, which is used by the fishermen to grease their masts; it is also sometimes used by painters, although Captain Atwood tells me he does not think it preferable in this respect to other fish-oil. It is considered by many fishermen a valuable application for sprains and bruises, and by such it is preserved for these purposes.

Upon the exterior of the specimens described in my "Report" were attached several parasites; at the base of, or near to the fins, a large number of the *Pennella sagitta* were found imbedded, with their pinnated extremities projecting like tentaculæ, and to them were firmly fixed specimens of the *Cineras vittata*. One beautiful specimen of the *Tristoma coccineum*, figured by Yarrell as being taken from this species, was found firmly attached to the posterior extremity of the fish. Closely attached to the branchiæ were a dozen or more specimens of the *Cecrops Latreillii*. The thickness of the exterior varies from two to three inches. A large number of *Tæniæ* were found in the intestines. Several *Cysticerci* were imbedded in the substance of the liver.

Massachusetts, Storer. New York, Mitchill, Dekay.

FAMILY XXV. BALISTIDÆ.

Body compressed. Snout prolonged from the eyes. Mouth small, with a few distinct teeth in each jaw. Skin roughened with prickles or scales. Dorsals, two; the anterior sometimes represented by a single spine. Ventrals often wanting or indistinct. Pelvic bone prominent.

GENUS I. MONACANTHUS, Cuv.

Body covered with very small scales, bristling with stiff excrescences, and extremely crowded. The extremity of the pelvis projecting and spiny, as in the *Balistes*, but they have only one large dentated spine to their first dorsal, or at least the second is almost imperceptible.

MONACANTHUS AURANTIACUS, *Dekay*.

The Orange File-fish.

(PLATE XXXIV. FIG. 3.)

Balistes aurantiacus, Orange File-fish, MITCH., Trans. Lit. and Phil. Soc. of N. Y., I. p. 468, pl. 6, fig. 1.
Monacanthus aurantiacus, Orange File-fish, DEKAY, Report, p. 333, pl. 57, fig. 186.
" " STORER, Proceed. Bost. Soc. Nat. Hist., II. p. 72.
" " " Mem. Amer. Acad., New Series, II. p. 496.
" " " Synopsis, p. 244.

Color. The greater portion of the fish is of an orange-yellow; the lower portion of the sides and beneath of a bluish-white.

Description. Body oval, compressed. Its entire surface covered by minute prickles, which are very obvious when the hand is drawn towards the head. Abdomen tumid. A slight concavity is noticed upon the forehead; the dorsal outline is horizontal. The greatest depth of the fish is just back of the pectorals. The length of the head is equal to about one quarter its entire length. The mouth is small, prominent, protruding. The lower jaw the longer, with eight flattened teeth; the front teeth large, flattened, emarginated above; the teeth in the lower jaw smaller and lanceolate. The eyes are large and circular, situated just beneath the dorsal spine. The branchial aperture, which is linear and nearly as long as the dorsal spine, is situated just beneath the eye. The nearly straight dorsal spine is equal to one half the length of the head; it is slightly rounded on its anterior edge, grooved at its posterior base, and exhibits numerous very minute serrations upon its posterior superior edge. A small membrane is attached to its base, posteriorly.

Just before the second dorsal fin, which commences on a line slightly anterior to the anal, is a prominent projection. This fin is rounded above. The middle rays are the longest; all the rays are more or less flattened.

The pectorals are broad and rounded, and situated on a line directly beneath the eyes.

The anal fin, resembling the dorsal in its appearance, terminates just posteriorly to that fin.

The caudal fin is composed of stout, bifurcated rays.

The fin rays are as follows: — D. 1, 35. P. 12. A. 39. C. 12.

Length, seventeen inches.

Remarks. The only individual of this species I have known to have been taken in our waters was captured at Salem, August, 1845. It belongs to the Natural History Society of that city, and was kindly loaned me by Dr. Wheatland, one of the Curators of the Society, to determine the species. The fish, when discovered, was swimming about two feet from the bottom, near the wharf, and from post to post, biting off the barnacles attached to them. When taken, and lying upon the wharf, it made a chirping noise like a bird, and endeavored to wound his captor with his spine. While dying, the color of the abdomen changed as in the dolphin.

The specimen referred to had been injured in its capture, being speared; and had lost its proportions by the process of drying, preventing me at the time from preparing an accurate description. My excellent friend, James Carson Brevoort, Esq., the distinguished ichthyologist of Brooklyn, New York, has kindly loaned me a specimen which has enabled me to present the above account. Dr. Dekay observes that this is a rare species in the waters of New York, he having seen but two specimens.

In August, 1842, the late lamented Charles D. Bates, M. D., formerly of the U. S. Navy, sent me a figure and description of this fish which was taken in the harbor of Portland, Maine, when he was attached to that station. He observes in his letter to me: "This fish appeared, about a fathom under water, like a bit of kelp, and was rising toward the surface, when a fisherman, observing its motion, put his hand into the water, and the fish came directly into it and was caught." He adds: "It is called Hog-fish vulgarly, either from its snout resembling that of this animal, or from a sort of short grunting noise it makes on being taken out of the water."

Maine, Massachusetts, STORER. Connecticut, LINSLEY. New York, MITCHILL, DEKAY.

MONACANTHUS MASSACHUSETTENSIS, *Storer.*

The Massachusetts File-fish.

(PLATE XXXIV. FIG. 4.)

Monacanthus Massachusettensis, Massachusetts File-fish, STORER, Report, p. 174.
" " " " DEKAY, Report, p. 336, pl. 57, fig. 187.
" " STORER, Mem. Amer. Acad., New Series, II. p. 496.
" " " Synopsis, p. 244.

Color. Of a yellowish-brown, variegated over its entire extent with brownish markings and blotches; more obvious upon upper portion of sides. Numerous minute white cilia are suspended from its sides.

Description. Body oblong, very much compressed. Surface granulated. Its depth from the base of the dorsal spine is equal to half the entire length of the fish. Length of head equal to one fourth the entire length. Jaws of equal length; teeth stout. Eyes circular, equal to one fourth the length of the head. A strong, granulated, curved spine, half the length of the head, with small sharp spines upon its posterior lateral edges pointing downwards and backwards, is situated just back of the centre of the eye.

The second dorsal fin commences some distance back of the spine; it is composed of colorless rays, which are roughened at their bases.

The pectorals also are colorless, and rounded when expanded.

The pelvic bone projects, is quite movable, and is connected by a dewlap to the abdomen.

The anal fin, of the same form as the dorsal, commences just posterior to that fin: the rays of this fin are granulated at their base like those of the dorsal.

The caudal fin is of a darker color than the other fins.

Length, four inches.

The fin rays are as follows: — D. 34. P. 12. A. 34. C. 12.

Remarks. I have seen but one specimen of this species. This was sent to me in 1838, by the late Dr. Yale of Holmes's Hole, as having been found in Massachusetts Bay.

Massachusetts, STORER. Connecticut, LINSLEY. New York, DEKAY.

MONACANTHUS SIGNIFER, *Storer*.

(PLATE XXXV. FIG. 1.)

Monacanthus setifer, DEKAY, Report, p. 337, pl. 59, fig. 194.
Monacanthus signifer, STORER, Mem. Amer. Acad., New Series, II. p. 497.
" " " Synopsis, p. 245.

Color. Of a reddish-brown color, with greenish reflections.

Description. Body elongated, compressed. The entire surface is very minutely granulated, by which a sensation of roughness is perceived, by the finger, over its whole extent, with the exception of the fleshy portion of the tail, and a small portion of the body just anterior to it; which parts are thickly studded with stiff setæ, looking and feeling like the teeth of a card, the points of which incline forwards, producing consequently this roughness only when the finger is drawn towards the tail.

The depth of the fish across the body from the base of the dorsal fin is less than half its length; the depth at the fleshy portion, to its greatest depth, is as one to four. The length of the head is equal to one fourth the entire length of the fish. The mouth is small. The teeth are sharp, and are four in number on each side. The eyes are circular. On the top of the head, back of the centre of the eyes, is situated a movable spine, terminating in a naked point, and armed posteriorly upon its sides with a number of small spines pointing downwards; these spines are more developed towards its upper portion.

The dorsal fin arises just back of the centre of the fish, and is nearly as long as the greatest depth of the fish; its second ray is the longest.

The pectorals commence on a line beneath the dorsal spine.

The pelvic bone is prominent, and terminates in a small stellated point; the dewlap to which it is attached is marked by large granulations, similar to those upon the rest of the surface.

The anal fin commences back of the dorsal; it is of a rounded form, and terminates opposite that fin.

The caudal fin is composed of very firm rays.

The fin rays are as follows: — D. 32. P. 16. A. 32. C. 10.

Length, five inches.

Remarks. Until the summer of 1842 I had not known of an individual of this species having been taken in the waters of this State. During that season, however, I saw specimens which had been caught at Hingham, Lynn, Nahant, and even in our harbor by means of seines. For the fine specimen from which my

drawing is made, I am indebted to John L. Tucker, Esq., formerly of the Tremont House of this city.

Previous to the appearance of Dekay's Report, I supposed this species to be Dr. Mitchill's *M. broccus*, and thus called it in the Proceedings of the Boston Society of Natural History, p. 84 (Sept. 1842).

Dekay described it as a new species, under the specific name of *setifer*. As, however, this name had been previously applied to another species of this genus by Bennett, in the Proceedings of the Zoölogical Society of London, Part I. p. 112, 1830, I have felt compelled to substitute another.

Massachusetts, Storer. New York, Dekay.

GENUS II. ALUTERES, Cuv.

An elongated body, covered with small and scarcely visible granules; a single spine in the first dorsal; the chief character is the pelvis, which is completely hidden under the skin, and is without that spinous projection observed in the other Balistes.

Aluteres cuspicauda, *Dekay.*

The Sharp-tailed File-fish.

(Plate XXXV. Fig. 2.)

Balistes cuspicauda, Sharp-tailed File-fish, Mitch., Amer. Month. Mag., ii. p. 326.
Aluteres monoceros, Unicorn File-fish, (Bloch,) Storer, Report, p. 175.
Aluteres cuspicauda, Long-tailed Unicorn-fish, Dekay, Report, p. 338, pl. 59, fig. 192.
" " " " Storer, Mem. Amer. Acad., New Series, ii. p. 497.
" " " " " Synopsis, p. 245.

Color. Coppery brown, with spots of pale bluish slate and of brassy yellow from the eyes to the tail and back half-way down the sides, arranged in rather regular series. Head, back, and throat of a dark olive-brown; lower part of sides and abdomen lighter. A pale greenish-blue tint on the cheeks and opercles. Irides brassy yellow. Dorsal spine dark. The last two thirds of the membrane of the caudal fin of a dusky brown, with the tips of the rays yellowish. The dorsal, pectorals, and anal almost colorless.

Description. Body elongated, compressed laterally. Its greatest height, which is just back of the dorsal spine, is equal to one third its entire length; its height at the base of the caudal rays is equal to about one fourteenth its length. Between the spine and the dorsal fin the back is nearly straight. The length of the head

is equal to one third the length of the fish. The facial angle is oblique, gradually sloping from the dorsal spine to the tip of the snout. The mouth is turned upwards. The teeth are sharp, pointed. The eyes are large and circular. The nostril is situated just in front of the anterior superior margin of the orbit. The branchial aperture is oblique.

The dorsal spine is short and serrated, having at its posterior base, connected by a membrane, a minute rudimentary spine.

The dorsal fin commences on the anterior half of the body; its central rays are the highest.

The pectoral fins are situated on a line beneath the eyes.

The anal fin commences opposite the dorsal, and terminates posterior to it.

The middle caudal rays are the highest; and all the rays, except the two outer, are filamentous.

Length, eight inches.

The fin rays are as follows, in four specimens:—

D. 2, 32.	P. 10.	A. 34.	C. 12.
D. 2, 36.	P. 12 or 13.	A. 36.	C. 12.
D. 2, 37.	P. 13.	A. 40.	C. 12.
D. 2, 38.	P. 13.	A. 42.	C. 12.

Remarks. I have seen a single specimen only of this species which has been taken in our waters. This was an immature fish sent me by Dr. Yale, from Holmes's Hole. As I had not met with Dr. Mitchill's paper on the "Fishes of New York," contained in the American Monthly Magazine, I described it in my "Report" as the *A. monoceros*, Bloch. Dekay, with recent specimens of the mature fish before him, was enabled to correct my error; and, through the kindness of J. Carson Brevoort, of Brooklyn, New York, to whom I have already expressed my indebtedness, I have been furnished with recent specimens, and notes, by which I am enabled to present the present description and remarks.

The color of this species varies exceedingly. Some specimens are almost as yellow as the *Monacanthus aurantiacus;* but most of them are of a dusky olive-brown, with cloudings of darker hue, and the series of spots of metallic brassy-yellow; while Dekay observes that he has seen them of a uniform brown, without any spots or clouds whatsoever. Brevoort tells me the species is very common in the month of September, and up to October 15th, in the narrow channels of the marshy Jamaica Bay. They are taken in nets altogether.

Massachusetts, STORER. New York, MITCHILL, DEKAY.

FAMILY XXVI. OSTRACIONIDÆ.

Body triangular or four-sided, enveloped in a hard bony case, composed of numerous plates, soldered together in such a manner that only the mouths and fins are movable. No ventral fins; a single dorsal.

GENUS LACTOPHRYS, Dekay.

Body triangular; with strong spines directed backwards before the anal fin. Orbits usually spinous.

Lactophrys Yalei, *Dekay*.

Yale's Trunk-fish.

(Plate XXXV. Fig. 3.)

Ostracion Yalei, Storer, Bost. Journ. Nat. Hist., I. p. 353, pl. 8.
" " *Yale's Trunk-fish*, Storer, Report, p. 176.
Lactophrys Yalei, *Yale's Trunk-fish*, Dekay, Report, p. 362.
" " Storer, Mem. Amer. Acad., New Series, II. p. 498.
" " " Synopsis, p. 246.

Color. Above, of a light leaden color; beneath, nearly colorless.

Description. Body triangular. Its entire surface is granulated and covered with hexagonal plates, each containing six raised lines, which diverge from the centre of the plate to the angles; these plates are much the larger posterior to the pectoral fins. From the posterior angle of the eye to the ligamentary substance at the base of the tail are included ten plates in a direct line; from the highest point of the back to the abdomen are nine similar rows of plates. Behind the dorsal fin is a surface of ligamentary substance, of a darker color than the rest of the exterior, extending to the caudal fin, and containing, just back of the dorsal fin, one isolated plate, apparently composed of portions of several plates. Upon the posterior portion of the abdomen are situated, laterally, two stout, naked, recurved spines. The mouth is large and prominent; the jaws are armed with elongated, strong teeth; the eyes are large, and elongated horizontally; the nostrils are directly anterior to the anterior inferior angle of the eye.

The fin rays are as follows: — D. 10. P. 12. A. 10. C. 10.

Remarks. The only specimen of this species which has been seen was discovered alive by Dr. Yale, in 1833, among the sea-weed on the beach at Martha's Vineyard, and was by him presented to the Boston Society of Natural History. In the

year 1836 I read a description of it to said Society, which was published in the first volume of their Journal, and afterwards in my "Report upon the Fishes of Massachusetts." This description I am again here compelled to present. The length of the specimen, in its dried state, is fourteen inches. From the contracted and wrinkled appearance of the ligamentary portion at the base of the tail, it must vary considerably from the size of the living fish.

Massachusetts, STORER.

CLASS II. CARTILAGINOUS FISHES.

Skeleton cartilaginous. Cranium divided by indistinct sutures. Gills generally fixed; the membrane without rays. Maxillary and intermaxillary bones either wanting or rudimentary; the palatines or vomer alone supplying their place.

ORDER I. ELEUTHEROPOMI.

Gills pectinated, free, as in ordinary fishes, with one large external aperture on each side, furnished with a strong opercle; without rays. Upper jaw formed by the palatine bone, firmly united to the maxillary; intermaxillary rudimentary.

FAMILY XXVII. STURIONIDÆ.

The genera of this family approach to ordinary fishes, by their gills being attached only at one extremity. They have but one branchial aperture, which is very open; they have but one operculum, and are without rays to the membrane of the gills.

GENUS ACIPENSER, LINN.

Body elongated and angular, defended by indurated plates and spines, arranged in longitudinal rows; snout pointed, conical; mouth placed on the under side of the head, tubular, and without teeth.

ACIPENSER OXYRINCHUS, *Mitchill.*

The Sharp-nosed Sturgeon.

(PLATE XXXV. FIG. 4.)

Acipenser Oxyrinchus, Sharp-nosed Sturgeon, MITCH., Trans. Lit. and Phil. Soc. of N. Y., I. p. 462.
" " LESUEUR, Trans. Amer. Phil. Soc., New Series, I. p. 394.
" " *Sharp-nosed Sturgeon,* STORER, Report, p. 178.
" " " " DEKAY, Report, p. 346, pl. 58, fig. 189.
" " AYRES, Fishes of Brookhaven, L. I., Bost. Journ. Nat. Hist., IV. p. 287.
" " LINSLEY, Cat. of Fishes of Connecticut, Amer. Journ. Science.
" " STORER, Mem. Amer. Acad., New Series, II. p. 499.
" " " Synopsis, p. 247.

Color. Of a grayish-brown color above; silvery upon the inferior portion of the sides; white beneath. Pupils black, irides yellow.

Description. Body elongated, pentagonal. Entire surface granulated, excepting that occupied by five longitudinal rows of flattened plates, of the same structure as the covering of the head, but of a lighter color. The largest plates form the dorsal ridge; in younger specimens these plates are compressed at their sides, and terminate above in strong, sharp, recurved spines; while in this the spines on the dorsal ridge in some plates are obsolete, and the whole crest a mere sharp edge, and are obvious only on a few of the plates; radiating lines are distinctly seen running from the centre of these scales to their circumference; this row is composed of ten plates. In the specimen formerly described by me, measuring two feet and three inches in length, this row contained twelve plates. The first are the largest; that at the commencement of the dorsal fin by far the smallest; between the dorsal and caudal fins are situated four plates. In the specimen described in my "Report" two quite small plates were seen just back of the dorsal, forming a pair; next to these a much larger one, and, lastly, an elongated one at the commencement of the caudal fin.

A second row of bony plates, twenty-eight in number, placed obliquely, commences just back of the operculum, situated where the lateral line is usually observed in fishes, and is continued to the base of the tail; these plates are narrowed to a point at their upper extremities, obtuse at their lower extremities, widened in their centres, and, like the former, are crowned by spines, more or less prominent, from the bases of which radii diverge. The posterior plates are much the smaller.

Beneath this row, just back of the pectorals, commences a third row of plates, eight in number, placed vertically, larger than those of the last row.

The head is flattened above, slightly depressed between the eyes, and terminates

at the occiput in a rounded plate, which in the immature fish is pointed. The whole upper portion of the head is bony, and irregularly marked upon its surface.

The snout is blunted. The eyes are small, and their diameter is less than one fifth the distance between them. The nostrils are double, situated directly in front of the eyes; the posterior is much the larger. The mouth, without teeth, capable of great protrusion, with fleshy, lobed lips, is situated on the under surface of the head; half-way between the mouth and the snout are situated four cirrhi placed transversely with respect to each other, nearly as long as the mouth.

The dorsal fin is situated far back, at the posterior extremity of the body; it is deeply emarginated; its first rays are higher than its length.

The pectorals arise from a strong, triangular plate; their first ray is very large and strong; the seventh and eighth are the highest; the length of the fins at their base are less than one half their height.

The ventrals, which are placed far back, are subquadrangular.

The anal fin is opposite the dorsal; its length is equal to one half its height; its posterior rays are equal in height to one third the height of the longest rays.

The upper lobe of the caudal fin is nearly double the length of the lower; the membranous structure of this fin renders it difficult accurately to determine the number of its rays.

The fin rays are as follows: — D. 38. P. 28. V. 24. A. 23. C. 125.

Length, six to ten feet.

Remarks. The largest specimen I have seen, nearly six feet in length, was found at Deer Island. It is sometimes taken measuring even ten feet. The specimen above described was captured in the harbor of Provincetown, and measured four feet and six inches in length.

But little attention has as yet been paid in this country to the value of the sturgeon fishery in an economical point of view. The several species we possess might unquestionably be made useful. The following observations of Professor B. Jaeger, contained in the nineteenth volume of Hunt's Merchants' Magazine, for 1848, are worthy of perusal.

"The principal sturgeon fisheries are, without doubt, those on the Volga, near Astracan, and those on the Don, which are carried on chiefly by the Cossacks of that country, who find this occupation much more lucrative than agriculture, which they neglect entirely, in spite of the very fertile soil of their lands.

"The fish forms an important object of fishery and commerce to many nations, as well for its flesh, as for the caviare prepared from its roe, and the isinglass from

its swimming-bladder. The city of Astracan exports every year several thousand tons of pickled sturgeon and caviare for consumption in the Russian empire; and Odessa much larger quantities for Greece, Italy, France, and other parts of Europe.

"When the catching of the sturgeons on the Oby, the Volga, Jaik, and Don begins, there arrive at these places, from the remotest parts of the Russian empire, a considerable number of merchants, who purchase the fish and prepare them for transportation. The average price of one fish, without the roe and swimming-bladder, is generally $4. A large one, which weighs over two hundred pounds, is sold at from $4 to $6, and contains forty pounds of caviare, or prepared roe, which is sold for $1.50.

"The flesh is fat, very palatable, and much better in the summer, after the fish has been some time in fresh water. That which is not eaten fresh is cut into large slices, salted, peppered, broiled, and put in barrels, where it is preserved in vinegar, and fit for transport. A considerable quantity of their flesh is smoked. The wholesale price of pickled sturgeon is from $6 to $12 a hundred-weight. The caviare is prepared in three different manners, namely: —

"1. Two pounds of salt are added to forty pounds of roe, and dried upon mats in the sun. The price of forty pounds is $1.

"2. Eight tenths of a pound of salt are mixed with forty pounds of roe, then dried upon nets or sieves, and pressed into barrels. This is sold for a little more.

"3. The best caviare is that when the roe is put into sacks made of tow-cloth, and left for some time in a strong pickle. These sacks are then suspended, in order to let the salt, watery substance run off, and finally squeezed, after which the roe is dried during twelve hours and pressed into barrels. This roe, of which forty pounds are sold for $1.50 at the place, is that which is sent all over Asia and Europe as a considerable article of commerce, and known by the name of caviare, and is eaten with bread like cheese.

"Another very profitable part of the sturgeon is the swimming-bladder, of which isinglass is made. For this purpose it is cut open, washed, and the silvery glutinous skin exposed to the air for some hours, by which process it can be easily separated from the external skin, which is of no use. This glutinous skin is placed between wet cloths, and shortly after each piece is rolled up and fastened in a serpentine form on a board; after they are partly dry they are hung up on strings in a shady place.

"This valuable and extensive article of commerce is the isinglass of our shops, and is sold there for about $50 a hundred-weight.

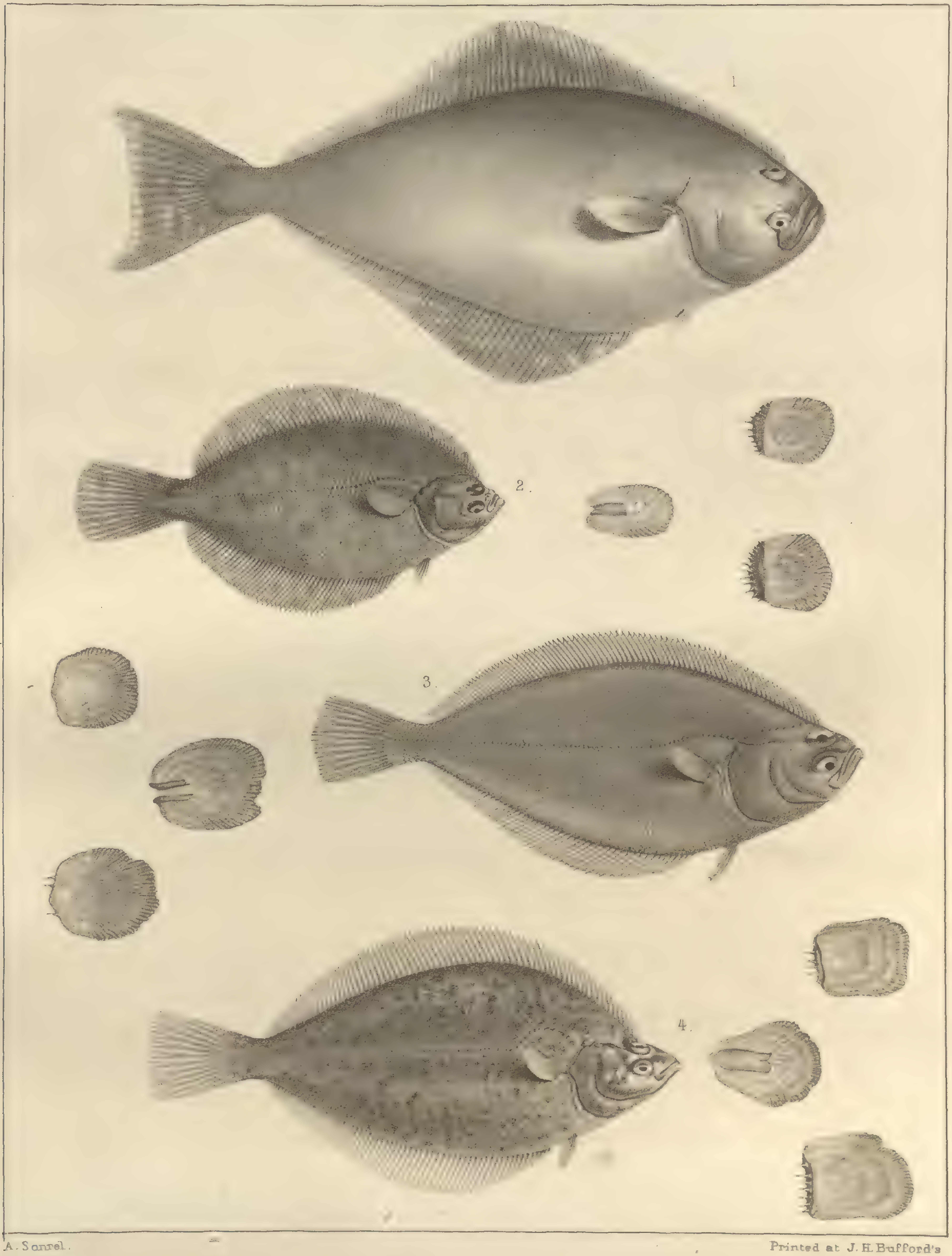
"There is made isinglass also from the swimming-bladder of the cat-fish, and of some others; but as this is very inferior to that from the sturgeon, it brings scarcely $10 a hundred-weight.

"The sturgeon is found in immense quantities in the United States and North America, from Virginia up to the highest habitable northern latitudes, where they ascend the rivers from three hundred to five hundred miles up. The Potomac, Delaware, Hudson, and principally the Kennebec, as well as many other rivers, contain such a quantity of sturgeons, that from those rivers alone, without counting those farther north of Maine, according to my calculation, the annual export of pickled sturgeon, caviare, and isinglass alone would be worth nearly half a million of dollars. Pickled sturgeon and caviare is a favorite food of the descendants of Spain and Portugal in South America, as well as of the inhabitants of the West India Islands, principally during Lent; and isinglass would be an article of home consumption, as well as for the European market.

"But the sturgeon is not a very favorite dish in our country; it brings scarcely five cents a pound in the market, and the roe and swimming-bladder are always thrown away. Our fishermen, therefore, are not much encouraged in catching these fishes, though, according to careful observations, from thirty thousand to forty thousand sturgeons could be annually caught in the rivers of the United States.

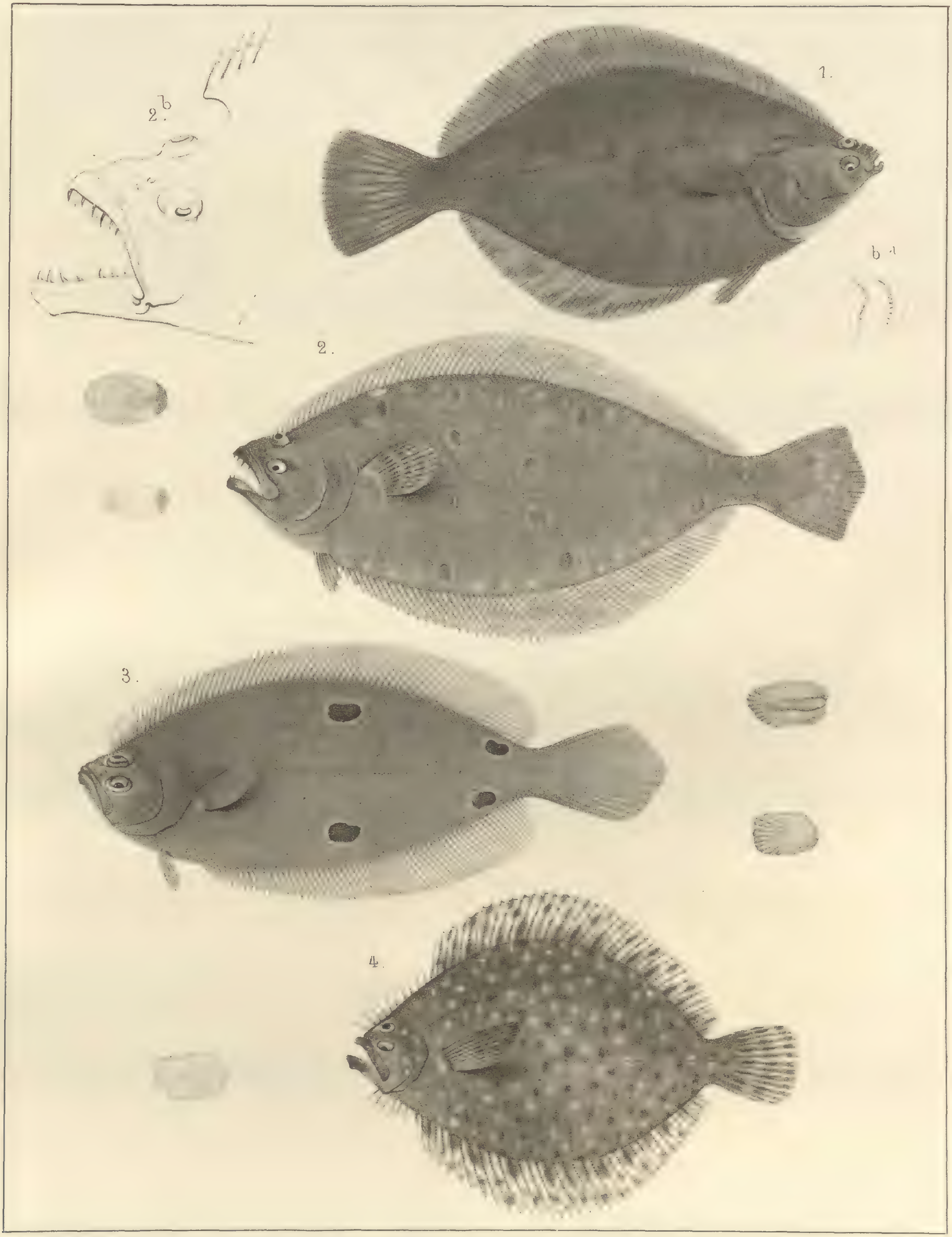
"The sturgeon was highly appreciated by the ancient Romans and Greeks. It was the principal dish at all great dinner-parties, and Cicero reproached epicures on account of their spending so much money for this fish. Pliny says that this fish was served at the most sumptuous tables, and always carried by servants, crowned with garlands of flowers, and accompanied by a band of musicians. And even at this time one pound of fresh sturgeon costs $4 in Rome, where this fish is very rare."

Massachusetts, Storer. Connecticut, Ayres, Linsley. New York, Mitchill, Dekay.



A. Sonrel. Printed at J. H. Bufford's

1. HIPPOGLOSSUS VULGARIS Cuv. — 2. PLATESSA PLANA Mitch.
3. PL. DENTATA Mitch. — 4. PL. FERRUGINEA Storer.



A. Sonrel & Tappan. Printed at J. H. Bufford's

1. PLATESSA GLABRA Storer — 2. PL. OBLONGA Dek.
3. PL. QUADROCELLATA Storer. — 4. PLEURONECTES MACULATUS Mitch.

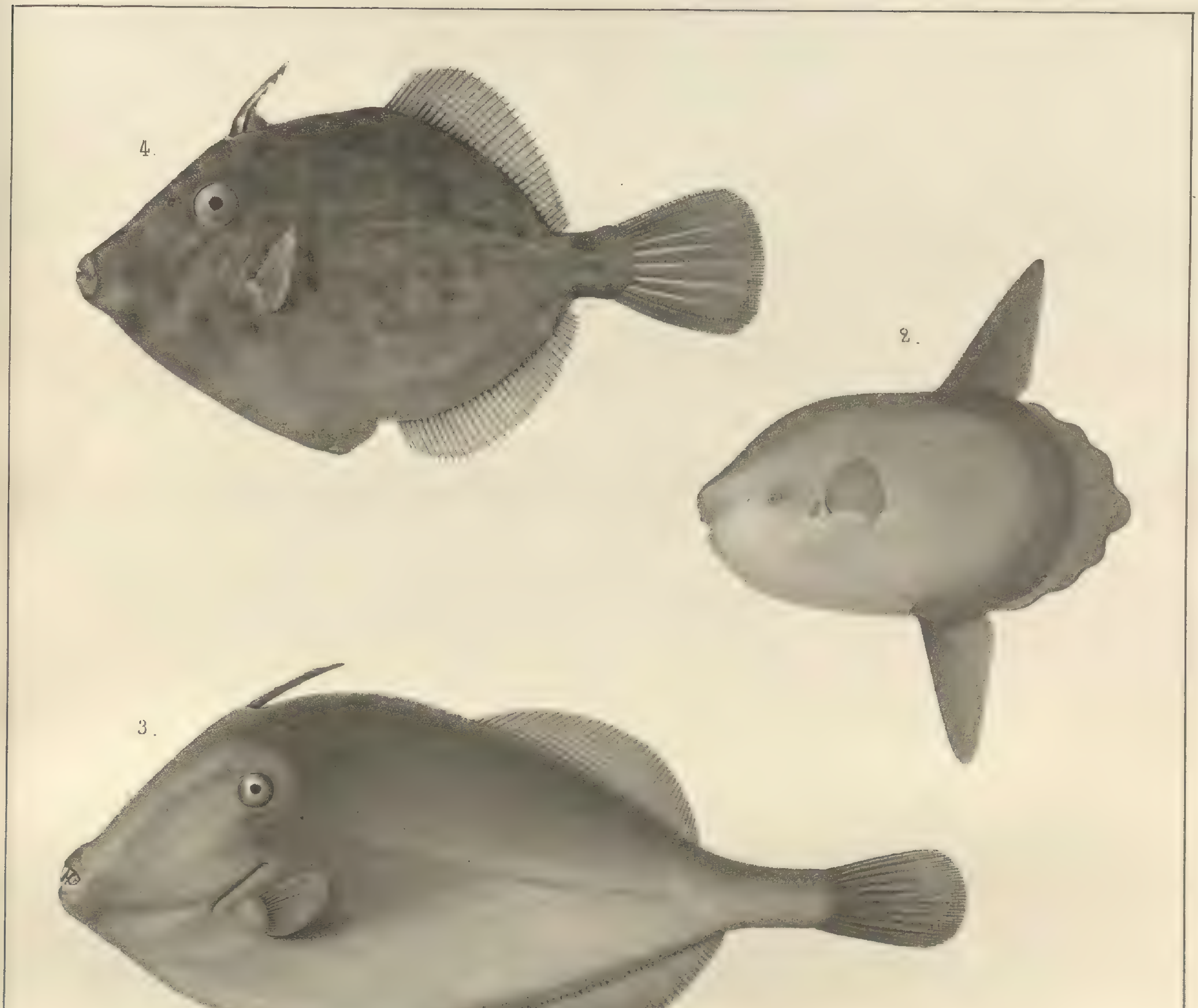
Tappan & Sonrel. Printed at J. H. Bufford's

1. ACHIRUS MOLLIS Cuv. — 2. LUMPUS ANGLORUM Will.
3. ECHENEIS ALBICAUDA Mitch. — 4. E. QUATUORDECIMLAMINATUS Storer.

Tappan & Sonrel

Printed at J. H. Bufford's.

1. ANGUILLA BOSTONIENSIS Dek. — 2. AMMODYTES AMERICANUS Dek.
3. SYNGNATHUS PECKIANUS Storer — 4. HYPPOCAMPUS HUDSONIUS Dek.
5. TETRAODON TURGIDUS Mitch.



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1 TETRAODON LAEVIGATUS Linn. — 2 ORTHAGORISCUS MOLA Schneider
3. MONACANTHUS AURANTIACUS Mitch — 4. M MASSACHUSETTENSIS Storer

Tappan & Sonrel. Printed at J. H. Bufford's.

1. MONACANTHUS SIGNIFER Storer. — 2. ALUTERES CUSPICAUDA Dek.
3. LACTOPHRYS YALEI Dek. — 4. ACIPENSER OXYRINCHUS Mitch.

XVI.

On Certain Forms of Interpolation.

By W. P. G. BARTLETT, A. M.

Communicated by PROFESSOR B. PEIRCE, *May* 13, 1862.

THE quantity to be interpolated being a function of t, the following scheme shows the notation and arrangement adopted for a series of its values and their *differences*.

(1) $$\begin{cases} f(t_0-1) = Y_{-1} & & \Delta^2_{-1} & & & \\ & \Delta_{-\frac{1}{2}} & & \Delta^3_{-\frac{1}{2}} & & \\ f(t_0) = Y_0 & & \Delta^2_0 & & \Delta^4_0 & \\ & \Delta_{\frac{1}{2}} & & \Delta^3_{\frac{1}{2}} & & \Delta^5_{\frac{1}{2}} \\ f(t_0+1) = Y_1 & & \Delta^2_1 & & \Delta^4_1 & \\ & \Delta_{\frac{3}{2}} & & & & \\ f(t_0+2) = Y_2 & & & \&c., & & \end{cases}$$

in which

(2) $$\begin{cases} \Delta_{n+\frac{1}{2}} = Y_{n+1} - Y_n, & \Delta^3_{n+\frac{1}{2}} = \Delta^2_{n+1} - \Delta^2_n, \\ \Delta^2_n = \Delta_{n+\frac{1}{2}} - \Delta_{n-\frac{1}{2}}, & \Delta^4_n = \Delta^3_{n+\frac{1}{2}} - \Delta^3_{n-\frac{1}{2}}, \quad \&c. \end{cases}$$

Whenever the subscript numbers are omitted in writing differences, $+\frac{1}{2}$ is to be understood for all odd orders, and 0 for all even ones.

It may be observed that, if we put $\Delta_{-\frac{1}{2}}$ in place of Y_0, we shall have the following relations between *its* differences and the original ones of Y_0:

(3) $$\begin{cases} \Delta_{\frac{1}{2}}(\Delta_{-\frac{1}{2}}) = \Delta^2_0, \qquad \Delta^2_0(\Delta_{-\frac{1}{2}}) = \Delta^3_{-\frac{1}{2}}, \quad \&c.; \\ \text{and similarly, if we put } \Delta^2_0 \text{ in place of } Y_0, \\ \Delta_{\frac{1}{2}}(\Delta^2_0) = \Delta^3_{\frac{1}{2}}, \qquad \Delta^2_0(\Delta^2_0) = \Delta^4_0, \quad \&c.; \end{cases}$$

and so on with higher orders of differences, the law of this *symbolic multiplication* being to add the subscript numbers of the *factors* to form that of the *product*, as well as their (exponential) indices to form its index.

Let i be a positive integer, and $k = \frac{1}{i}$; then after the insertion between Y_n and Y_{n+1} of $i-1$ new values of the function (which is called *interpolating to* k^{ths}), let a portion of the series and its differences be

$$
(4)\quad \left\{
\begin{array}{lllll}
y_{-1} & & & & \\
 & \vartheta_{-\frac{1}{2}} & & & \\
Y_0 & & \delta_0^2 & & \delta_0^4 \\
 & \vartheta_{\frac{1}{2}} & & \vartheta_{\frac{1}{2}}^3 & \cdot \\
y_1 & & \vartheta_1^2 & & \cdot \\
 & \vartheta_{\frac{3}{2}} & & \vartheta_{\frac{3}{2}}^3 & \cdot \\
y_2 & & \vartheta_2^2 & & \\
\cdot & \cdot & \cdot & \cdot & \\
\cdot & \cdot & \cdot & \cdot & \\
\cdot & \cdot & \cdot & \cdot & \\
\cdot & \cdot & \cdot & \cdot & \\
y_{i-1} & & \vartheta_{i-1}^2 & & \\
 & \vartheta_{i-\frac{1}{2}} & & \vartheta_{i-\frac{1}{2}}^3 & \\
Y_1 & & \delta_1^2 & & \\
 & \vartheta_{i+\frac{1}{2}} & & \&c. & \\
y_{i+1} & & & &
\end{array}
\right.
$$

The quantity ϑ will be an implicit function of t, the values indicated in (4) corresponding to $t = t_0 - \frac{1}{2}k$, $t_0 + \frac{1}{2}k$, $t_0 + \frac{3}{2}k$, &c.; let its value for $t = t_0 \pm \frac{1}{2}$ be $\delta_{\pm\frac{1}{2}}$. δ_0^2 will then, *in all cases, whether i is odd or even*, be the same function of $\delta_{-\frac{1}{2}}$ and *its* differences that $\delta_{\frac{1}{2}}$ is of Y_0 and its differences; that is, if

(5) then

$$\delta_{\pm\frac{1}{2}} = \varphi_{\pm\frac{1}{2}}(Y_0),$$

$$\delta_0^2 = \varphi_{\frac{1}{2}}(\delta_{-\frac{1}{2}}) = \varphi_{\frac{1}{2}} \cdot \varphi_{-\frac{1}{2}}(Y_0) = \varphi_0^2(Y_0);$$

and similarly for similar functions of higher orders:

$$\delta_{\pm\frac{1}{2}}^3 = \varphi_{\pm\frac{1}{2}}(\delta_0^2) = \varphi_{\pm\frac{1}{2}} \cdot \varphi_{\frac{1}{2}} \cdot \varphi_{-\frac{1}{2}}(Y_0) = \varphi_{\pm\frac{1}{2}}^3(Y_0),$$

$$\delta_0^4 = \varphi_{\frac{1}{2}}(\delta_{-\frac{1}{2}}^3) = \varphi_{\frac{1}{2}} \cdot \varphi_{-\frac{1}{2}} \cdot \varphi_{\frac{1}{2}} \cdot \varphi_{-\frac{1}{2}}(Y_0) = \varphi_0^4(Y_0), \text{ \&c.};$$

φ^n representing the result of the n successive functional operations indicated in each third member.

From the well-known development

$$(6)\quad y_h = y_0 + h\Delta_{\pm\frac{1}{2}} + \frac{h(h \mp 1)}{2}\Delta_0^2 + \frac{(h+1)h(h-1)}{2 \cdot 3}\Delta_{\pm\frac{1}{2}}^3 + \frac{(h+1)h(h-1)(h \mp 2)}{2 \cdot 3 \cdot 4}\Delta_0^4 + \text{\&c.},$$

is directly obtained

$$(7)\qquad \varphi_{\pm\frac{1}{2}} = \delta_{\pm\frac{1}{2}} = k\left[\Delta_{\pm\frac{1}{2}} - \frac{1-k^2}{4 \cdot 2 \cdot 3}\Delta_{\pm\frac{1}{2}}^3 + \frac{1-k^2}{4 \cdot 2 \cdot 3} \cdot \frac{3^2-k^2}{4 \cdot 4 \cdot 5}\Delta_{\pm\frac{1}{2}}^5 - \text{\&c.}\right],$$

which is a *linear function* of certain differences, which are themselves *linear functions*; therefore φ^n is obtained by n symbolical multiplications of the series (7) according to the law (3). The subscript numbers are seen to result so that, omitting them from the operation, we have $\delta^n =$ *the symbolical* n^{th} *power of* δ; that is

$$(8)\qquad \delta = k\left[\Delta - \frac{1-k^2}{24}\Delta^3 + \frac{1-k^2}{24} \cdot \frac{9-k^2}{80}\Delta^5 \ldots\right],$$

(9) $$\delta^2 = k^2\left[\Delta^2 - \frac{1-k^2}{12}\Delta^4 + \frac{1-k^2}{12}\cdot\frac{4-k^2}{30}\Delta^6\ldots\right],$$

(10) $$\delta^3 = k^3\left[\Delta^3 - \frac{1-k^2}{8}\Delta^5 + \frac{1-k^2}{8}\cdot\frac{37-13k^2}{240}\Delta^7\ldots\right],$$

(11) $$\delta^4 = k^4\left[\Delta^4 - \frac{1-k^2}{6}\Delta^6 + \frac{1-k^2}{6}\cdot\frac{7-3k^2}{40}\Delta^8\ldots\right],$$

(12) $$\delta^5 = k^5\left[\Delta^5 - \frac{5}{24}(1-k^2)\Delta^7\ldots\right].$$

It will be observed that the notation δ^{2n}_m was substituted in (4) for each difference of the form ϑ^{2n}_{mi}, because the symbolic even powers of δ as there defined are *always* identical with ϑ^{2n}_{mi}. When i is odd, δ^{2n+1} is also identical with the middle ϑ^{2n+1} between Y_0 and Y_1; and all the series (8) . . . (12) may be used directly. When i is even, let δ'^{2n+1} denote half the sum of the two ϑ^{2n+1}s next above and below the middle point between Y_0 and Y_1; then in each case it will be the same function of δ^{2n}_0 and *its* differences, that δ' is of Y_0 and its differences; that is, if

(13) $$\delta' = \varphi'(Y_0), \qquad \text{then} \qquad \delta'^{2n+1} = \varphi'(\delta^{2n}_0).$$

But we have for these functions of k, *whether* $\frac{1}{2}$ *i is odd or even,*

(14) $$\delta'(k) = \tfrac{1}{2}\delta(2k); \qquad \text{that is,} \qquad \varphi'(k) = \tfrac{1}{2}\varphi_i(2k);$$

therefore the series for δ'^{2n+1} may be obtained by substituting $2k$ for k in (7) and symbolically multiplying this into the series for $\frac{1}{2}\delta^{2n}$. This gives

(15) $$\delta' = k\left[\Delta - \frac{1-4k^2}{24}\Delta^3 + \frac{1-4k^2}{24}\cdot\frac{9-4k^2}{80}\Delta^5\ldots\right],$$

(16) $$\delta'^3 = k^3\left[\Delta^3 - \frac{1-2k^2}{8}\Delta^5 + \left(\frac{1-2k^2}{8}\cdot\frac{19-12k^2}{120} - \frac{1}{1920}\right)\Delta^7\ldots\right],$$

(17) $$\delta'^5 = k^5\left[\Delta^5 - \frac{5-8k^2}{24}\Delta^7\ldots\right].$$

Besides the symmetrical relations obtained above by introducing the functions δ, the following may be obtained directly from (6):—

(18) $$\vartheta_{\frac{1}{2}} = \theta_{\frac{1}{2}} - \theta^2_0, \qquad \vartheta_{i-\frac{1}{2}} = \theta_{\frac{1}{2}} + \theta^2_1;$$

(19) $$\begin{cases} \vartheta_{\frac{1}{2}} + \vartheta_{-\frac{1}{2}} = \theta_{\frac{1}{2}} + \theta_{-\frac{1}{2}}, \\ \vartheta_{\frac{1}{2}} - \vartheta_{-\frac{1}{2}} = \delta^2_0; \end{cases}$$

in which

(20) $$\theta_{\pm\frac{1}{2}} = k\left[\Delta_{\pm\frac{1}{2}} - \frac{1-k^2}{2.3}\Delta^3_{\pm\frac{1}{2}} + \frac{1-k^2}{2.3}\cdot\frac{2^2-k^2}{4.5}\Delta^5_{\pm\frac{1}{2}} - \&c.\right],$$

$$(21)\qquad \Theta_n^2 = \tfrac{1}{2}k(1-k)\left[\Delta_n^2 - \frac{1+k}{3}\cdot\frac{2-k}{4}\,\Delta_n^4 + \frac{1+k}{3}\cdot\frac{2-k}{4}\cdot\frac{2+k}{5}\cdot\frac{3-k}{6}\,\Delta_n^6 - \&c.\right].$$

Since the functions involved in (19) need not be restricted to integral values of i, similar expressions may be obtained for the differences between Y_0 and $y_{\pm m}$ by substituting $m\,k$ for k in (9) and (20). By arranging these according to powers of $m\,k$ and using their differences taken with respect to m, algebraic expressions may easily be got for any of the differences ϑ_h^n. To do this let m^r be substituted for y_m in the series (4); and, $\nabla^n m^r$ being one of the nth order of differences of the new series, let $\vartheta_h^n\,(m)$ be the *correspondingly placed* difference of the series y_m: then

$$(22)\qquad \begin{cases} \vartheta_h^n(-m) = \Phi_0^{[n]}(m) - \Psi_0^{[n]}(m), \\ \vartheta_h^n(m) \quad\;\; = \Phi_0^{[n]}(m) + \Psi_0^{[n]}(m); \end{cases}$$

in which, putting

$$(23)\qquad \Delta_0^{2n-1} = \tfrac{1}{2}\left(\Delta_{-\frac{1}{2}}^{2n-1} + \Delta_{\frac{1}{2}}^{2n-1}\right) = \Delta_{-\frac{1}{2}}^{2n-1} + \tfrac{1}{2}\Delta_0^{2n},$$

$$(24)\qquad \begin{cases} \Phi_0^{[n]}(m) = \nabla^n m\,.\,k\left(\Delta_0 - \tfrac{1}{6}\Delta_0^3 + \tfrac{1}{30}\Delta_0^5\right) + \nabla^n m^3\cdot\dfrac{k^3}{6}\left(\Delta_0^3 - \tfrac{1}{4}\Delta_0^5\right) + \nabla^n m^5\cdot\dfrac{k^5}{120}\Delta_0^5 + \&c., \\ \qquad\qquad = \nabla^n m\,.\,k\,\Delta_0 - \left(\dfrac{\nabla^n m}{k^2} - \nabla^n m^3\right)\cdot\dfrac{k^3}{6}\left(\Delta_0^3 - \tfrac{1}{5}\Delta_0^5\right) - \left(\dfrac{\nabla^n m^3}{k^2} - \nabla^n m^5\right)\cdot\dfrac{k^5}{120}\Delta_0^5 + \&c., \\ \Psi_0^{[n]}(m) = \nabla^n m^2\cdot\dfrac{k^2}{2}\left(\Delta_0^2 - \tfrac{1}{12}\Delta_0^4 + \tfrac{1}{90}\Delta_0^6\right) + \nabla^n m^4\cdot\dfrac{k^4}{24}\left(\Delta_0^4 - \tfrac{1}{6}\Delta_0^6\right) + \nabla^n m^6\cdot\dfrac{k^6}{720}\Delta_0^6 + \&c. \end{cases}$$

Formula (22) is a *perfectly general connection between the original and the interpolated differences of any order.*

When $n=1$, (22) gives the means of deriving all the first differences,* ϑ_h, by computing the functions (24) for $\frac{i}{2}$ or $\frac{i-1}{2}$ different values of m, according as i is even or odd, — in the latter case obtaining $\vartheta_{\frac{1}{2}} = \delta_{\frac{1}{2}}$ from (8). For this method the second form of Φ is adapted. But methods of this sort, however simplified in numerical application, seem unnecessarily laborious.

Any interpolation may be made by combining (8) or (15) with (9), as follows. Compute the δ^2 opposite each value of Y, and the δ or δ' opposite each interval. Then from the former fill in all the second differences, ϑ_h^2, and by their means the first differences, ϑ_h, and thence the function itself. If i is even, the two differences $\vartheta_{\frac{i-1}{2}}$ and $\vartheta_{\frac{i+1}{2}}$, of which δ' is half the sum, must be derived from δ' and the second difference, $\vartheta_{\frac{i}{2}}^2$, opposite it, by taking the sum and difference $\delta' \mp \frac{1}{2}\vartheta_{\frac{i}{2}}^2$. This method is sometimes the most convenient, especially when $i = 5$. If the higher differences are

* For another method of this sort, with a different system of differences, see Mr. Ferrel's article on *Interpolation* in the *Mathematical Monthly*, Vol. III. p. 377.

very large, the ϑ^2_hs must themselves be interpolated, either by a distinct operation, or by the use of (10) or (16) and (11).*

An objection to these processes, when many interpolated values are to be inserted, is that the sum of the computed first differences will not generally be exactly equal to the differences between two successive values of Y; nor will the sum of the computed second differences exactly fill in the computed first differences, etc. These difficulties have to be remedied by subsequent arbitrary correction, or by computing the higher differences to one or more decimal places beyond those of Y. For this reason, interpolation to fourths, sixths, ninths, &c. should generally be done by successive interpolations to halves and thirds; and the choice of the special method of doing this must depend more or less upon the particular character of the function to be interpolated. The following are some practical methods with the numerical coefficients in the various series required.

Interpolation to Halves.

(21″) $$\Theta^2_n = \tfrac{1}{8}\left[\Delta^2_n - \tfrac{3}{16}\Delta^4_n + \tfrac{3}{16}\cdot\tfrac{5}{24}\Delta^6_n \cdots\right],$$

(15″) $$\delta' = \tfrac{1}{2}\Delta,$$

(9″) $$\delta^2 = \tfrac{1}{4}\left[\Delta^2 - \tfrac{1}{16}\Delta^4 + \tfrac{1}{16}\cdot\tfrac{1}{8}\Delta^6 \cdots\right].$$

The interpolated differences may be obtained in successive pairs by taking the half-sum and half-difference of the quantities

(25) $$\begin{cases} \vartheta_{\frac{3}{2}} + \vartheta_{\frac{1}{2}} = \Delta = 2\delta', \\ \vartheta_{\frac{3}{2}} - \vartheta_{\frac{1}{2}} = \Theta^2_0 + \Theta^2_1 = \vartheta^2_1. \end{cases}$$

When ϑ^2_1 can readily be obtained by interpolating the δ^2_hs, it may be more convenient to use (9″) instead of (21″) to obtain it.

Interpolation to Thirds.

(20‴) $$\Theta_{\pm\frac{1}{3}} = \tfrac{1}{3}\left[\Delta_{\pm\frac{1}{3}} - \tfrac{4}{27}\Delta^3_{\pm\frac{1}{3}} + \tfrac{4}{27}\cdot\tfrac{7}{36}\Delta^5_{\pm\frac{1}{3}} \cdots\right];$$

(21‴) $$\Theta^2_n = \tfrac{1}{9}\left[\Delta^2_n - \tfrac{5}{27}\Delta^4_n + \tfrac{5}{27}\cdot\tfrac{28}{135}\Delta^6_n \cdots\right];$$

(8‴) $$\delta = \tfrac{1}{3}\left[\Delta - \tfrac{1}{27}\Delta^3 + \tfrac{1}{27}\cdot\tfrac{1}{9}\Delta^5 \cdots\right],$$

(9‴) $$\delta^2 = \tfrac{1}{9}\left[\Delta^2 - \tfrac{2}{27}\Delta^4 + \tfrac{2}{27}\cdot\tfrac{7}{54}\Delta^6 \cdots\right].$$

* This general method, *as far as relates to odd values of i*, with algebraic forms for $\delta^{2n-1}_{\frac{1}{2}}$ and δ^{2n}_0 up to $n = 4$, is given by Encke in the *Astronomische Nachrichten*, Band 29, No. 695. Also a partial statement, obtained by *induction* apparently, of the symbolic connection of the series (8) . . . (12).

Formula (19) is sufficient to do the whole interpolation, using $(20''')$ and $(9''')$. But it is often better (especially when, in interpolating to sixths or twelfths, it is desirable not to write down the inserted values of the function themselves, till the whole is finished, but only their differences) to use $(8''')$ and $(21''')$, as follows:—

(26) $$\begin{cases} \vartheta_{\frac{5}{6}} + \vartheta_{\frac{1}{6}} = \Delta - \delta, & \vartheta_{\frac{1}{2}} = \delta, \\ \vartheta_{\frac{5}{6}} - \vartheta_{\frac{1}{6}} = \Theta_0^2 + \Theta_1^2. \end{cases}$$

Interpolation to Fourths.

(20^{IV}) $$\Theta_{\pm\frac{1}{2}} = \tfrac{1}{4}\left[\Delta_{\pm\frac{1}{2}} - \tfrac{5}{32}\Delta^3_{\pm\frac{1}{2}} + \tfrac{5}{32}\cdot\tfrac{63}{320}\Delta^5_{\pm\frac{1}{2}} \dots\right],$$

(15^{IV}) $$\delta' = \tfrac{1}{4}\left[\Delta - \tfrac{1}{32}\Delta^3 + \tfrac{1}{32}\cdot\tfrac{7}{64}\Delta^5 \dots\right],$$

(9^{IV}) $$\delta^2 = \tfrac{1}{16}\left[\Delta^2 - \tfrac{5}{64}\Delta^4 + \tfrac{5}{64}\cdot\tfrac{21}{160}\Delta^6 \dots\right],$$

(11^{IV}) $$\delta^4 = \tfrac{1}{256}\left[\Delta^4 - \tfrac{5}{32}\Delta^6 \dots\right].$$

Instead of interpolating twice to halves, $\vartheta_{\frac{1}{8}}$ and $\vartheta_{\frac{7}{8}}$ may be got by (19), using (20^{IV}) and (9^{IV}), and $\vartheta_{\frac{3}{8}}$ and $\vartheta_{\frac{5}{8}}$ by

(27) $$\begin{cases} \vartheta_{\frac{5}{8}} + \vartheta_{\frac{3}{8}} = 2\,\delta' = \Delta - (\vartheta_{\frac{1}{8}} + \vartheta_{\frac{7}{8}}), \\ \vartheta_{\frac{5}{8}} - \vartheta_{\frac{3}{8}} = \vartheta_2^2. \end{cases}$$

Either the second or third member of the first equation may be used; and ϑ_2^2 may be got by interpolating δ^2 to halves, using for this purpose (11^{IV}) if necessary.

Interpolation to Fifths.

(20^{V}) $$\Theta_{\pm\frac{1}{2}} = \tfrac{1}{5}\left[\Delta_{\pm\frac{1}{2}} - \tfrac{4}{25}\Delta^3_{\pm\frac{1}{2}} + \tfrac{4}{25}\cdot\tfrac{99}{500}\Delta^5_{\pm\frac{1}{2}} \dots\right],$$

(8^{V}) $$\delta = \tfrac{1}{5}\left[\Delta - \tfrac{1}{25}\Delta^3 + \tfrac{1}{25}\cdot\tfrac{14}{125}\Delta^5 \dots\right],$$

(9^{V}) $$\delta^2 = \tfrac{1}{25}\left[\Delta^2 - \tfrac{2}{25}\Delta^4 + \tfrac{2}{25}\cdot\tfrac{33}{250}\Delta^6 \dots\right],$$

(10^{V}) $$\delta^3 = \tfrac{1}{125}\left[\Delta^3 - \tfrac{3}{25}\Delta^5 + \tfrac{3}{25}\cdot\tfrac{19}{125}\Delta^7 \dots\right],$$

(11^{V}) $$\delta^4 = \tfrac{1}{625}\left[\Delta^4 - \tfrac{4}{25}\Delta^6 \dots\right].$$

If, besides getting $\vartheta_{\frac{1}{2}} = \delta$ from (8^{V}), we use (20^{V}) and (9^{V}) in (19) to get $\vartheta_{\frac{1}{10}}$ and $\vartheta_{\frac{9}{10}}$, there will remain only $\vartheta_{\frac{3}{10}}$ and $\vartheta_{\frac{7}{10}}$ to be filled in.

Interpolation to Sixths.

(20^{VI}) $$\Theta_{\pm\frac{1}{2}} = \tfrac{1}{6}\left[\Delta_{\pm\frac{1}{2}} - \tfrac{35}{216}\Delta^3_{\pm\frac{1}{2}} + \tfrac{35}{216}\cdot\tfrac{143}{720}\Delta^5_{\pm\frac{1}{2}} \ldots\right],$$

(15^{VI}) $$\delta' = \tfrac{1}{6}\left[\Delta - \tfrac{1}{27}\Delta^3 + \tfrac{1}{27}\cdot\tfrac{1}{9}\Delta^5 \ldots\right],$$

(9^{VI}) $$\delta^2 = \tfrac{1}{36}\left[\Delta^2 - \tfrac{35}{432}\Delta^4 + \tfrac{35}{432}\cdot\tfrac{143}{1080}\Delta^6 \ldots\right],$$

(16^{VI}) $$\delta'^3 = \tfrac{1}{216}\left[\Delta^3 - \tfrac{17}{144}\Delta^5 + \left(\tfrac{17}{144}\cdot\tfrac{7}{45} - \tfrac{1}{1920}\right)\Delta^7 \ldots\right],$$

(11^{VI}) $$\delta^4 = \tfrac{1}{1296}\left[\Delta^4 - \tfrac{35}{216}\Delta^6 \ldots\right].$$

If $\vartheta_{\frac{1}{2}}$ and $\vartheta_{\frac{11}{2}}$ are computed by (19), and $\vartheta_{\frac{5}{2}}$ and $\vartheta_{\frac{7}{2}}$ by using (15^{VI}) and (9^{VI}), there will remain only $\vartheta_{\frac{1}{3}}$ and $\vartheta_{\frac{2}{3}}$ to be filled in.

It will be observed that the series (8) . . . (12) and (15) . . . (17) always converge more rapidly than (20) and (21); and their use should sometimes be preferred on this account. A little reflection will often introduce, instead of the above-written fractions, some simpler equivalents, which may be mentally applied to the requisite degree of accuracy. Thus, in the examples given below, the following have occurred:—

$$\tfrac{3}{16} = \tfrac{1}{5} - \tfrac{1}{80}, \qquad \tfrac{7}{36} = \tfrac{1}{5} - \tfrac{1}{180},$$

$$\tfrac{4}{27} = \tfrac{1}{7} + \tfrac{1}{189}, \qquad \tfrac{14}{125} = \tfrac{1}{9} + \tfrac{1}{1125};$$

in all of which the right-hand term is easily applied when not small enough to be neglected.

The function Y, in the examples given below, is the Moon's declination for 1865, omitting the degrees; the values are taken where their higher differences are quite large. Two methods of interpolating to sixths (by halves and thirds, and then by thirds and halves) are given, and their results may be compared. For computing a lunar ephemeris, the first method here given has been found to possess peculiar advantages. An example of interpolating to fifths, i. e. to every tenth of a day, is then given on Encke's plan. The whole of the work which it is necessary to write down is printed. The columns headed S . 8 Θ^2, &c. contain the sums of each consecutive pair of values of the functions 8 Θ^2, &c. Since the sum and difference of any two numbers must be both odd or both even, in using (25) and (26) the nearest odd or even value has been taken for S . Θ^2, according as Δ and $\Delta - \delta$ were odd or even; and similarly with δ^2 and ϑ_1^2 in using (19) and (9″). In the interpolation to fifths, the computed third and second differences, ϑ^3 and ϑ^2, happen *exactly* to fill in the second and first respectively, all being carried to hundredths of a second, i. e. one place farther than the function Y.

Date.	Funct., Y.	Δ	Δ^2	Δ^3	Δ^4	Δ^5	Functions for Interpolation to Halves by (25). $\frac{3}{16}\Delta^4$	$8\,\Theta^2$	$S.8\,\Theta^2$	$S.\Theta^2$
d	′ ″	′ ″	′ ″	″	″	″	″	″	″	″
Apr. 27.5	38 2.6		—18 7.9		+27.9		+5.2	—1093.1		
		+20 54.2		+23.7		—4.1			—2161.8	—270.2
28.0	58 56.8		17 44.2		23.8		4.5	1068.7		
		+ 3 10.0		47.5		5.0			2088.9	261.2
28.5	62 6.8		16 56.7		18.8		3.5	1020.2		
		—13 46.7		66.3		6.1			1973.0	246.7
29.0	48 20.1		15 50.4		12.7		2.4	952.8		
		—29 37.1		+79.0		—5.3			—1825.6	—228.1
29.5	18 43.0		—14 31.4		+ 7.4		+1.4	— 872.8		

Functions for Interpolation to Thirds by (19).

Date.	$\Delta^3 - \frac{7}{36}\Delta^5$	$3\,\Theta$	$S.3\,\Theta$	$\frac{12}{27}\Delta^4$	$9\,\delta^2$	$S.\Theta$	δ^2
d	″	′ ″	′ ″	″	″	′ ″	″
Apr. 27.5							
	+24.5	+20 50.6					
28.0			+23 53.4	+1.8	—1066.0	+ 7 57.8	—118.4
	48.5	+ 3 2.8					
28.5			—10 53.9	1.4	1018.1	— 3 38.0	113.2
	67.5	—13 56.7					
29.0			—43 45.7	+0.9	— 951.3	—14 35.2	—105.8
	+80.0	—29 49.0					
29.5							

Functions for Interpolation to Fifths by (8^{v}), (9^{v}), and (10^{v}).

Date.	$\Delta^3 - \frac{14}{125}\Delta^5$	$5\,\delta$	$\frac{2}{25}\Delta^4$	$25\,\delta^2$	$125\,\delta^3$
d	″	′ ″	″	″	″
Apr. 27.5			+2.2	—1090.1	
	+24.2	+20 53.23			+24.2
28.0			1.9	1066.1	
	48.1	+ 3 8.08			48.1
28.5			1.5	1018.2	
	67.0	—13 49.38			67.0
29.0			1.0	951.4	
	+79.6	—29 40.28			+79.6
29.5			+0.6	— 872.0	

After Interpolation to Halves by (25).					For Interpolation to every 2 Hours by (26).			
Date.	Δ	Δ^2	Δ^3	Δ^4	δ	$S.9\,\Theta^2$	$\Delta-\delta$	$S.\Theta^2$
d h	′ ″	″	″	″	′ ″	″	′ ″	″
Apr. 27 12								
	+12 42.2							
27 18		—270.2		+1.6				
	8 12.0		+3.8		+2 44.0	—537.2	+5 28.0	—59.6
28 0		266.4		1.4				
	+ 3 45.6		5.2		+1 15.1	528.2	+2 30.5	58.7
28 6		261.2		1.6				
	— 0 35.6		6.8		—0 12.0	516.1	—0 23.6	57.4
28 12		254.4		0.9				
	4 50.0		7.7		1 36.8	501.5	3 13.2	55.8
28 18		246.7		1.2				
	8 56.7		8.9		2 59.0	484.9	5 57.7	53.9
29 0		237.8		0.8				
	12 54.5		+9.7		—4 18.3	—466.1	—8 36.2	—51.8
29 6		—228.1		+0.4				
	—16 42.6							
29 12								

After Interpolation to Thirds by (19).						For Interpolation to every 2 Hours by (9″).	
Date.	ϑ	Function.	Δ	Δ^2	Δ^3	δ^2	ϑ_1^2
d h	′ ″	′ ″	′ ″	″	″	″	″
Apr. 27 20		53 58.7					
	+4 58.1		+4 58.1				
28 0		58 56.8		—118.4		—29.6	
	+2 59.7		2 59.7		+1.4		—29.5
4		61 56.5		117.0		29.3	
			+1 2.7		1.9		29.1
8		62 59.2		115.1		28.8	
	—0 52.4		—0 52.4		1.9		28.6
12		62 6.8		113.2		28.3	
	2 45.6		2 45.6		2.4		28.0
16		59 21.2		110.8		27.7	
			4 36.4		2.5		27.4
20		54 44.8		108.3		27.1	
	6 24.7		6 24.7		+2.5		—26.7
29 0		48 20.1		—105.8		—26.4	
	—8 10.5		—8 10.5				
29 4		40 9.6					

Interpolation by using (25), and then (26).			Interpolation by using (19), and then (9″).	
Date.	ϑ	Function.	ϑ	Function.
d h	′ ″	′ ″	′ ″	′ ″
Apr. 28 0		58 56.8		58 56.8
	+1 44.6		+1 44.6	
2		60 41.4		60 41.4
	1 15.1		1 15.1	
4		61 56.5		61 56.5
	0 45.9		0 45.9	
6		62 42.4		62 42.4
	+0 16.9		+0 16.8	
8		62 59.3		62 59.2
	—0 12.0		—0 11.9	
10		62 47.3		62 47.3
	0 40.5		0 40.5	
12		62 6.8		62 6.8
	1 8.7		1 8.8	
14		60 58.1		60 58.0
	1 36.8		1 36.8	
16		59 21.3		59 21.2
	2 4.5		2 4.5	
18		57 16.8		57 16.7
	2 31.9		2 31.9	
20		54 44.9		54 44.8
	2 59.0		2 59.0	
22		51 45.9		51 45.8
	—3 25.8		—3 25.7	
29 0		48 20.1		48 20.1

Interpolation to Fifths by (10ᵛ), (9ᵛ), and (8ᵛ).				
Date.	ϑ^3	ϑ^2	ϑ	Function.
d	″	″	′ ″	′ ″
Apr. 27.9	+0.27	—42.91		56 12.2
			+2 44.57	
28.0	0.31	42.64*		58 56.8
			2 1.93	
28.1	0.35	42.33		60 58.7
			1 19.60	
28.2	0.38*	41.98		62 18.3
			+0 37.62*	
28.3	0.42	41.60		62 55.9
			—0 3.98	
28.4	0.45	41.18		62 52.0
			0 45.16	
28.5	0.48	40.73*		62 6.8
			1 25.89	
28.6	0.51	40.25		60 40.9
			2 6.14	
28.7	0.54*	39.74		58 34.8
			2 45.88*	
28.8	0.56	39.20		55 48.9
			3 25.08	
28.9	0.58	38.64		52 23.8
			4 3.72	
29.0	+0.60	38.06*		48 20.1
			—4 41.78	
29.1		—37.46		43 38.3

* These are the independent values derived from the original differences.

XVII.

Observations on the Language of Chaucer.

(Based on Wright's Edition of the Canterbury Tales, Harleian MS. No. 7334.)

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The object of this paper is to do something towards ascertaining the forms of words used by Chaucer. This is a matter which is entirely unsettled, though a right understanding of it is of great importance for the history of English, and an indispensable preliminary to the constructing of an accurate text of the poet. In seeking to throw some light upon the many questions involved, some of which I have not the least expectation, and do not make the slightest pretence, of deciding at present, I shall not go beyond Wright's edition of the Canterbury Tales, which I have reason to believe a substantially correct reproduction of one of the best manuscripts. The Canterbury Tales do not indeed comprise the half of all Chaucer's poetry, but they extend to more than seventeen thousand verses, in the course of which it is clear that all the most important grammatical forms must repeatedly occur. The utility, for our purpose, of an examination of the rest of the poems would therefore not be great, even were they accessible in a trustworthy shape: and this is not the case. On the other hand, a comparison of several, if not all, of the best manuscripts of the Canterbury Tales, is of the greatest consequence, and since such a comparison, under existing circumstances, cannot be made, many difficulties, as will soon be seen, must be left undecided. Still, a careful and minute inspection of *one* good text of the Canterbury Tales cannot fail to yield results of *some* value; for, should no other purpose be answered, the points in the subject of inquiry that most need elucidation will at any rate be strongly brought out.

It must perhaps be acknowledged to be an extraordinary thing, and to English-

men humiliating, that, though Chaucer has had a real popularity of nearly five hundred years, no readable edition of any part of his works, not even of the glorious Canterbury Pilgrimage, has been given to the world, — readable, I mean, to a person who is exacting with regard to grammar, and who insists on having the genuine forms of Chaucer's English; for the merits of Tyrwhitt's labors in other respects can never be denied. It may not be a matter of surprise that Englishmen should only of late have begun the study of the history of their language *for the intrinsic interest of the subject*, but it does seem a little remarkable that the transcendent excellence of Chaucer, which has always been more or less felt and confessed, should not long ago have excited attention to the laws of the English tongue at his particular epoch. It is quite certain, however, that we ourselves have not yet much to boast of, unless it be a little more curiosity, and we must take care that the mere accident of our living at a time when the philology of the modern languages is a favorite study do not make us unjust to our predecessors. We are a long way off from a knowledge of the English of the fourteenth century, and still further from a satisfactory edition of Chaucer.

Indeed, there is reason to doubt (and the editors may find some comfort in the thought) whether there ever was an accurate copy of a poem by Chaucer, except his own, or a manuscript corrected by his hand. Certainly this would not be an absolutely extravagant inference from what he says "unto his own Scrivener."

> "Adam Scrivener, if ever it thee befalle,
> Boece or Troilus for to write newe,
> Under thy long locks thou maist have the scalle,
> But after my making thou write more trewe!
> So oft a day I mot thy werke renewe,
> It to correct, and eke to rubbe and scrape;
> And all is thorow thy negligence and rape."

Adam Scrivener was only the first in a long line of corrupters, all of whom must take their share of the imprecation pronounced upon carelessness and haste. But we are not to put all the blame off upon the crime of Adam and his tribe. Adam may have been heedless and stupid; but, however heedless and stupid, he might justly plead the unsettled state of the language in part excuse. It was undoubtedly very hard for an humble scribe to remember and observe all the nice differences between the courtly style of his patron and the vulgar dialect, and numerous errors were inevitable. These errors would of course be multiplied in a second copy, for "no ass has written but some ass has read." In view of the want of

uniformity in the language and of the negligence of copyists, Chaucer thought the prospect of his verses being preserved as he wrote them very unpromising, and he expresses his apprehension thus in an important passage towards the end of Troilus and Cressida:

> "And for there is so gret diversité
> In Englissh and in writynge of our tonge,
> So preye I God that non myswrite the,
> Ne the mysmetere for defaute of tonge."

This anxiety of Chaucer about the writing and reading of his verses was a thousand times justified by the course of events. If he could not get his poems correctly transcribed and pronounced in his own day, there was no sort of chance that his language and metre would pass unscathed through the revolution English was to undergo in the next century, even on the supposition that some care was taken to perpetuate the original. But no such care was taken. On the contrary, if we are to believe Mr. Wright, "copyists invariably altered what they copied to the form of the language at the time in which they wrote, and, which is still more embarrassing, to the local dialect of the county in which they lived." When manuscripts ceased to be produced, there was naturally a conclusion to the multiplication of diversity in this way. Such errors and alterations of copyists as had been made were then fixed by printing, and to these were added the usual blunders of the press and the deliberate corruptions of editors.

As the old printed editions of Chaucer have been entirely superseded, we need not spend time upon them. The Canterbury Tales were first printed about 1475, by Caxton, from a bad manuscript, and six years after from a better. Some ten reprints, with the addition of other poems, followed, the last in 1721, by Urry, whose only rule for editing Chaucer was his own ignorant fancy, and who produced, as Tyrwhitt gently says, by far the worst text that was ever published. The first serious attempt to restore the genuine text of the Canterbury Tales was made by Tyrwhitt in 1775, three hundred years after they were first printed by Caxton. Tyrwhitt's edition of the Canterbury Tales has enjoyed the highest reputation, and the estimation in which it has been held is in great part deserved, and ought to be permanent. He "collated or consulted" about twenty-five manuscripts, illustrated the Tales with many admirable notes, to which very little has since been added, and drew up a very good Glossary of the whole works of Chaucer. The weak point of Tyrwhitt's edition of the Canterbury Tales is the text, which was formed on a wrong principle and without sufficient philological knowledge. Tyrwhitt, to be sure, made some attempt to ascertain the laws of Chaucer's language,

and the comparative value of the manuscripts he employed, but the grammatical rules he has given us are both inadequate and inaccurate, while he puts at the head of the five manuscripts to which he ascribes most credit a very "incorrect and carelessly written volume,"* part vellum, part paper (Harl. MS. 7335), and excludes from this list the very best manuscript in the Museum (Harleian 7334). We do not know on what principles the order of the manuscripts used was settled, but correct philological principles were certainly not the guide. One manuscript was taken as a standard for a time, then another, and then a third. The impropriety of such a procedure is obvious on a moment's reflection, and will be forcibly felt, if what has been said of the unsettled state of English at the end of the fourteenth century, and of the liberties taken by copyists, is borne in mind. The natural result of an arbitrary compounding of a dozen manuscripts, representing the dialects of various dates and localities, (not without an admixture of the idiosyncrasies of their respective writers,) is an artificial text, conformable to the actual speech of no time, place, tribe, or individual. And this, so far as we can see, was the process of Tyrwhitt.†

The Harleian manuscript No. 7334 was made the basis of a new edition of the Canterbury Tales, prepared by Mr. Wright for the Percy Society (1847–51). This manuscript was "collated throughout" with the Lansdowne MS. 851, in the British Museum (which seems to be Tyrwhitt's W), and as far as the Wife of Bath's Tale with two others. The collations, however, do not extend to grammatical minutiæ, and though the editor informs us that he has corrected many obvious errors, we may regard the text as essentially a reprint of the Harleian MS. 7334. As such it is of great value, but it is, nevertheless, by no means a satisfactory, or even a comfortably readable text. The number of manifest errors still left is considerable, the number of probable ones enormous. Hundreds of lines are incomplete, and long passages exhibit much irregularity of language and metre. On

* These are the words of Sir Frederic Madden, in answer to an inquiry of mine.

† Through the kindness of my friend, H. T. Parker, Esq. of London, a zealous lover of Chaucer, I have in my possession Tyrwhitt's original collations of nearly all the MSS. in the Museum and at Cambridge mentioned in his list. The Oxford collations are not included. Tyrwhitt took an old printed copy, and corrected it minutely on the margins according to the various MSS. which he adopted as authoritative, sometimes changing at an interval of less than a page, sometimes keeping on with one and the same for ten pages. He then entered the various readings of other MSS. on blank leaves. Those marked in his list A, C, C_1, T, W, are most used. The marginal corrections are, more than half the time, made according to A, the inferior codex spoken of above; about one third of the time according to C_1. C (the excellent Harleian MS. 7334) is the guide for only the first two pages of the Prologue, but is collated throughout. For exactness' sake, I mention that the Persones Tale is wanting in these collations, except the very beginning.

the other hand, there are long passages which appear to be but very slightly corrupted from the original, the metre being regular, and certain plain grammatical laws uniformly observed.*

Whether the day will ever come when a text of Chaucer will be constructed upon just principles, is more than can be predicted.† Manuscripts of the Canterbury Tales and of Troilus and Cressida are very numerous, but no pains have been taken to collect a list of those that are known, or to settle their relative value. Had Chaucer been a German, the existing manuscripts would have been zealously hunted up, strictly classified, and faithfully compared and studied, and we should have had only too many editions. It is not desirable that a new edition of Chaucer should be undertaken, until a man is found who is both competent to the task and willing to make thorough work with the manuscripts. It is, therefore, perhaps to be regretted that Mr. Bell's eight neat volumes, recently published, ever saw the light, as they are likely to block the way to something better for a good while.

That diversity in English which made Chaucer apprehensive of damage to his verses may have been so considerable, that we could not be sure of restoring them to perfect purity, even if we had several manuscripts of the date 1400 before us. But by far the larger part of the irregularities and corruptions with which the text is now loaded are undoubtedly of later origin, and there is no reason why, (if we are allowed only to take for granted that Chaucer had an ear, and meant to write good metre,‡) by taking pains enough, by a patient comparison of apparently un-

* Naturally enough, it is often the less interesting passages which are most incorrect; for instance, the Monk's Tale, which almost made "oure ost" fall down for sleep, and seems to have had the same effect upon the copyist.

† And whether an attractive and easily intelligible *popular* edition of the Canterbury Tales is, for moral reasons, desirable, is more than I will assert.

‡ Of course, unless Chaucer wrote good metre, there is an end to all inquiry into the forms of his language. Nothing can be more absurd than Dr. Nott's theory upon this point (Surrey and Wyatt, Vol. I., Dissertation), or more just than Tyrwhitt's remarks, which, however, did Nott no good. "The great number of verses, sounding complete even to our ears, which is to be found in all the least-corrected copies of his works, authorizes us to conclude that he was not ignorant of the laws of metre. Upon this conclusion, it is impossible not to ground a strong presumption that he intended to observe the same laws in many other verses which seem to us irregular; and if this was really his intention, what reason can be assigned sufficient to account for his having failed so grossly and repeatedly, as is generally supposed, in an operation which every ballad-monger in our days, man, woman, or child, is known to perform with the most unerring exactness, and without any extraordinary fatigue?" (*Essay*, Part. II. § xii.) Tyrwhitt was perfectly right in saying that the greatest part of Chaucer's heroic verses, when properly written and pronounced, are of eleven syllables. Whether the eleven-syllable verse is as agreeable to us as the decasyllabic, is another matter. Is it not surprising, then, that a man of

corrupted verses, followed by a collation of good contemporary manuscripts, and of the forms of earlier and contemporary authors, we should not at last obtain a text approximately correct, and perhaps better than most of those in circulation at his own day. I have in these notes attempted only to make a beginning, by setting down minutely all the principal forms of words found in one copy of the Canterbury Tales, equally those which conform to rule and those which do not. While passing over as of no consequence irregularities found in imperfect or otherwise faulty verses, I have taken care not to force any verse into conformity with supposed rule, by making emendations, however probable. The number of exceptions to such rules as I have thought myself justified in laying down, is sometimes considerable. A comparison of another manuscript of the same class and age as the Harleian 7334, would test the reality of these exceptions, and I think would cause many of them to disappear. I am in hopes soon to be able to employ for this purpose an exact copy of the beautiful manuscript formerly belonging to the Duke of Bridgewater, and now in the possession of Lord Ellesmere, which, to judge from the Prologue, the only portion I have as yet seen, affords a most excellent text. I must also call attention to the fact that sufficient care is not taken by editors of ancient manuscripts to render correctly the contracted terminations used by the scribes. It is unnecessary to point out, that, unless these terminations have been faithfully attended to and rightly interpreted in the printed copy of the manuscript I have used, many irregularities and errors may arise from that cause alone. There are countless cases in which a final *n* (indicated in manuscripts by a stroke over the foregoing vowel) may be presumed to have existed originally, though not preserved in this manuscript.

The purpose of this paper being, as stated at the beginning, to do something towards ascertaining the forms of words used by Chaucer (including inflections), the notes upon that subject are intended to be complete, to the extent of the information to be derived from the one text employed. Not so with the Miscellaneous Notes, subjoined to the others.

A partial examination of Gower (in the new edition, which is much more handsome than accurate) shows that he employs substantially the same forms as Chaucer. Nevertheless, there are slight differences. A thorough comparison both of the Con-

sense and taste should write as follows? "At the same time, many of his lines evidently consist (even on this theory) of ten syllables only; and such a construction of verse, for ordinary purposes, is become so much more agreeable to modern usage and taste, *that his poetry had better be so read whenever it can be done, even at the cost of thereby somewhat violating the exactness of the ancient pronunciation.*" — Craik's Hist. Eng. Lit., I. 249.

fessio Amantis and of Piers Ploughman is much to be desired. Passing by inflections, many English words which now end in a consonant formerly ended in a vowel. When did the change take place? The shortening process seems to have begun by Chaucer's time, but not to have been far advanced. The question has not been hitherto made of any importance, but it is of great consequence, and ought plainly not to be neglected in the new Dictionary of the Philological Society, from which so much is hoped. In the Rules prescribed by the Committee of this Society, collectors are enjoined in general terms to notice all the varieties of form that are now obsolete, but in a special rule they are told that "*wode* for *wood* and *sunne* for *sun* are unimportant." Is it likely that, without more explicit directions, all the obsolete varieties of form will receive due attention?

Among Mr. Guest's many contributions to our knowledge of the English language, there are very valuable remarks on Chaucer in the History of English Rhythms, and in the Proceedings of the Philological Society. I must also, while differing from some of the author's views, mention with great respect an essay on the Language of Chaucer, based on Tyrwhitt's text, by F. G. Gesenius (*De Lingua Chauceri*, a Doctor's Dissertation, Bonn, 1847). Mr. Gesenius has continued his study of Chaucer, and has communicated papers deserving attention to the *Archiv für das Studium der neueren Sprachen.*

NOTATION. — The numbers refer to the text of the Canterbury Tales, as printed in three volumes by the Percy Society. A reprint of this text in Cooke's *Universal Library* was used for some time, on account of the convenience of having the whole in a single volume, and it is possible that there may be a few discrepancies between the two impressions. There are also a few errors in the numbering of the lines in the Percy Society edition, and now and then certain doubtful lines are not counted in the numbering, which nevertheless are here referred to in regular order. It can be only extremely seldom (if ever) that embarrassment will arise from any of these causes, and the matter is alluded to merely to forestall the suspicion of even a trifling carelessness.

The prose parts of the Canterbury Tales are referred to by volume and page of the Percy Society edition.

The sign f following a number denotes that the word referred to is the *final* word of the verse. S. denotes Anglo-Saxon, L. Layamon, O. the Ormulum, rh. rhymed with.

The sign (ˆ) is here used to denote *all* long vowels in Saxon words, without distinction of variety; the double dot (¨) over a vowel, to denote that the vowel is pronounced; the italic type, to denote a vowel elided; (˘) to indicate that a vowel (not elided) is silent (or slurred over); the grave accent, to mark the emphatic syllable of a word. The acute accent will be used only with words which in French end in é, in which cases the vowel is so marked in the original text.

Words or letters *added* to the text are enclosed in brackets, as [e]: words or letters which I think ought to be omitted from the text are enclosed in parentheses, as (e).

I have generally used Ettmüller's *Lexicon Anglosaxonicum* (Quedlinburg and Leipsic, 1851), in preference to Bosworth.

NOUNS.

§ 1. **Nouns which in Anglo-Saxon end in a vowel terminate in Chaucer uniformly in ë.**

§ 2. First Declension of Anglo-Saxon Nouns. Neuters. (I. 1. Rask.)

eere (S. eâre, O. ære), 6218, 6603 f, 8603 f.
yhe, yë (S. eâge, O. eȝhe), 10 f, 3018 f, 4700 f, 8109 f, etc.

§ 3. Masculines. (I. 2.)

ape (S. apa), 3933, 7046 f, 13241 f, 15396 f.
asse (S. assa, O. asse), 16798 f.
balke (S. balca, bolca), 3918 f.
bane (S. bana, bona, L. bone, bane), 1099, 1683 f, 16446 f.
bere (S. bera), 2144, 1642 f. [2060 f, ĕ?]
bi-leeve (S. ge-leâfa, L. i-læfe, O. læfe), 3456, 11445 f, 11991 f, 12355 f.
bowe (S. boga), 17044, 108 f, 9888 f, 17061 f.
bowĕ, 2897.
clifte (S. clŷfa), 7727 f.
crede (S. crêda), 12975 f.
crouke (S. crocca), 4156 f.
cuppe (S. cuppa, L. cuppe), 134, 10930 f.
drope (S. dropa, L. drope), 12450 (131, bad line).
dwale (S. dwala), 4159 f.

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blosme (S. blôstma, blôsma, O. blosstme), 3324 (blosm*e* upon).

fane (S. fana), 8872 f.
feere (S. fêra, ge-fêra, L. i-vere*), 4748 f, 4815 f, 6506 f, 8989 f.
foode (S. fôda, O. fode), 7463 f.
galle (S. gealla, O. galle), 6522 f, 11986 f, 12725 f, 15833 f.
grame (S. grama, L. grame), 13331 f.
hare (S. hara), 191 f, 686 f, 1812 f, 15167 f.
harre (S. heorra), 552 f.
hawe (S. haga), 6240 f, 14270 f.
hiwe (S. hîwa), 9659 f.
housbonde, housëbonde (S. husbonda, L. husbonde, hosebonde), 6034 f, 6062 f, 14578 f, 5612 f, 5959 f.
housbond, 6085, 8597, (6107?): housëbond, 16850: housëbondĕ, 8574.
hope (S. hopa, L. O. hope), 12798, 2437, 10802, 12606 f.
hopĕ, 88.
hunte (S. hunta, L. hunte, O. hunnte), 2020.
hunt, 2014, bad line; 2630, hunt[*e*] as.
hyne (S. hîna), 605 f, 13247 f.
knave (S. cnafa, cnapa, L. cnave, O. cnape), 3434, 3469, 5135, 5142, 8320, 8323, etc.

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gere (S. gearwa, geara), 367? 354 f? ger, 2182 f?

* i-vere*n* also occurs; but it may be observed, once for all, that that form of noun, frequent in Layamon, is not cited in these lists.

knotte (S. cnotta), 10715, 10721.
kyte (S. cita, cyta), 1181, 10938, 10939.
lappe (S. lappa), 688 f, 8461 f, 10949 f, 11940 f.
leere (S. lîra), 15268 f.
lippe (S. lippa), 133.
make (S. maca, O. macche, make), 5667, 2558 f, 5120 f, 12152 f, 15203 f.
mawe (S. maga), 4906 f, 15234 f, 14411 f.
moone (S. môna, L. O. mone), 3515, 4296, 9759, 11599.
mouthe (S. mûtha), Derte-mouthe, 391 f.
name (S. nama, L. name, nome, O. name), 1439, 1588, 12030, 12384, etc.
 namĕ, 15128 : perhaps we should read "name is."
nekke (S. hnecca), 238, 1220, 3916, 5859, etc.
 nek-bon, 6488? nekkë boon, 16548.
oxe (S. oxa, O. oxe), 8083, 13769, 16490, 16513.
poke (S. poca), 3778, 4276 f.
pope (S. papa, L. pape), 8678, 263 f, 645 f.
pride (S. prŷta, also prŷt, II. 2, L. prude, prute), 897 f, 9867 f, 14314 f, 15674 f, etc.
prikke (S. pricca), 4539 f.
reeve (S. rêfa, L. reve), 589, 617, 3901, 4323.
schrewe (S. screawa), 17083, 5866 f, 5873 f, 6087 f, [etc.
spearwe (S. spearwa), 628 f, 7386 f.
stake (S. staca), 8580 f, 669 f.
steede (S. stêda, L. stede), 2159, 2729, 10484, 15162, etc.
 steedĕ, 10438?
steere (S. steôra, O. *ster*), 4868 f, 5253 f.
sterre (S. steorra, L. steorre, sterre, O. sterrne), 2061 f.
stikke (S. sticca), 13193, 13199.
tene (S. teôna, L. teone, O. tene), 3108 f.
tyme (S. tîma, L. O. time), 44, 722, 864, 4056, 4448, etc. (24 cases.)
 tymĕ, 9678, 10327, 10790, 12976, etc. (14 cases.)
wele (S. wela, L. wele), 1274 f, 3103 f, 13530 f.
 welĕ, 8847.
welle (S. wella, also wylle, I. 3, well, II. 2, L. welle), 5597, 7924, 1535 f, 11689 f.
 wellĕ, 8091.
wete (S. wæta, also wæte, I. 3, O. wæte), 13115 f.
wille (S. willa, also wille, I. 3, L. wille, O. wille), 2671, 7986, 8202, 10315, etc.
 another form: will (S. will, II. 2, L. i-wil, O. will), 3875, 3878, 3885, 8052, etc.
 willĕ, 11016?
wrecche (S. wrecca, L. wræcche, O wrecche), 933, 7645 f, 12396 f, 13014 f.

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schoppe (S. sceoppa?), 4376, 4374 f.
stele (S. stela, Jun. ap. Bosw., stæl, II. 2, Ettm.), 3783 f, 6531 f.
webbe (S. webba), 364, "a webbe, a dyer."

§ 4. Feminines. (I. 3.)

almesse (S. ælmæsse, O. *allmess*), 4588 f.
arwe (S. arewe, L. arewe, arwe), 11424.
belle (S. belle, O. belle), 171 f, 14077 f, 14407 f, 16266 f.
berye (S. berige, berie), 207 f.
cappe (S. cappe), 588 f, 687 f, 3145 f.
cheeke (S. cêce, ceâce), 6374 f, 15524 f: cheekĕ, 15529, — bad verse.
chirche (S. cyrice, L. chirche, O. kirrke), 7391, 7775, 13744, 13793, etc.
cloote (S. clate), 12505.
cote (S. cote), 2459 f.
crowe (S. crâwe), 17175, 17062 f, 17294 f, 2694 f.
 crow, 17172.
deepe (S. dŷpe, deôpe), 4875 f.
dowfe (S. dûfe), 10013, 13812.
erthe (S. eorthe, L. O. eorthe, erthe), 1248, 8079, 8557, 10707.
flye (S. fleôge, flŷge), 4350, 14582 f, 10178 f.
glose (S. glôse), 7374 f, 7502 f.
harpe (S. hearpe, L. harpe), 6039.
heepe (S. heôpe), 15158 f.
heire (S. hære, L. here), 12061 f.
herte (S. heorte, L. heorte, O. heorrte, herrte), 955, 956, 1146, 2651, 6354, etc. (40 cases.)
 hertĕ, 10526, 8062, 9113, 16301 : hert, 9113. (7 cases.)
hose (S. hose, L. hose), 3931 f.
howve (S. hûfe), 3909 f.
larke (S. lâverce), 1493, 2212.
lilie (S. lilje), 2180, 12019, 12015 f, 11955 f.
mare (S. mere, myre), 17010 f, 4053 f, 693 f.
masse (S. mæsse, L. masse, O. messe), 7331, 9768, 14662, 15047.
myte (S. mîte), 1560 f, 7543 f, 12439 f, 12561 f.
nightyngale (S. nihtegale), 98 f, 3377 f, 15245 f, [17068 f.
oule (S. ûle), 6663 f.

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wone (S. wuna, L. wune), 337 f? 14915 f? wonĕ, 1066.
wright' (S. wyrhta, L. wurhte), 616 : wright[*e*], a carpenter?
birch' (S. birce, also birc, II. 3), birch' asp, 2923?

panne (S. panne), 13243, 13138 f, 7196 f.
pan, rh. *man*, 1167, 15438!
pipe (S. pîpe), 567.
pirie (S. pirige), 10091 f, 10099 f.
pisse-myre (S. -mîre), 7407 f.
pose (S. ge-pose, Bosw.), 4150 f, 16994 f.
rake (S. race), 289 f.
rose (S. rôse), 1040, 13448.
scheete (S. scŷte, scête), 12807 f.
schere (S. sceare), 15542 f.
schire (S. scire), 358 f, 586 f.
schyne (S. scine), 388: "that on his schynë — a mormàl hadde he."
side (S. sîde, O. side), 1277, 2736, 9808, 9821, etc.
snare (S. sneâre, Bosw.), 1492 f, 4991 f, 17009 f.
sonne (S. sunne, L. sunne, sonne, O. sunne), 30, 1511, 2524, 10484, etc.
swalwe (S. swalewe), 3258.
targe (S. targe), 473 f, 977 f.
throte (S. þrote), 2460 f, 3218 f.
tonge (S. tunge, L. O. tunge), 3894, 5319, 7232, 13813, etc., etc.
tongĕ, 10349.
tonne (S. tunne, L. tunne), 1996, 5759, 3892 f, 8091 f.
trappe (S. treppe, O. *trapp*), 11653 f, 11939 f.
wake (S. wæcce, O. wecche), 2960, 2962.
wenche (S. wencle, O. *wennchell*), 3971, 4165, 4192, 6944, etc.
wicche-craft (S. wicce, O. wicche), 6885.
wise (wîse, L. O. wise), 9927, 17309, 5312, 5692, etc.
wisĕ, 2189.

§ 5. In the following the final **e** has been absorbed by *y* or *w*.*

play (S. plega, L. plæȝe), 1127 f, 8906 f, 9404 f, 14528 f.
lady (S. hlæfdige, L. læfdi, O. laffdiȝ), 1145, 1351, 1351, 14885.
sty (S. stîge), 7411 f.

herberw, herberwh, herbergh (S. hereberge, L. herberwe, O. herrberrȝhe), 405, 767, 4117, 4143, 11347.
widow, widw (S. widuwe, L. widewe, O. widewe, widdwe), 6609, 6626, 7166, 7201, 14913, 14920, 16307.
But widowë, widewë, 14997, 255. See § 91 b.

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tapstere (S. tæppestre), 241 f? tapster, 3336.

* nevew, 15890, is from the French *neveu*, not from S. *nefa*, whence comes the Old English and modern colloquial form *neve*, *nevie*.

In the following the final **e** seems to have been transposed from after *l* (as is often the case after *r*).

fithul (S. fithele), 298.
ladel (S. hlædle), 2022, 16983.
wesil (S. wæsle), 3234.
whistel (S. hwistle), 4153.

§ 6. The following cases are exceptions to §§ 3, 4.

pith (S. pitha), 6057 f.
beech (S. bôce, beôce), 12856 f: 2925?
kers (S. cerse), 3754 f.
stot (S. stotte), 7125, 7212, 617 f.

§ 7. Second Declension of Anglo-Saxon Nouns. — Masculines. (II. 2.)

awe (S. ege, L. eȝe, O. aȝhe), 656 f, 16045 f.
bale (S. bealu, L. balu, bale), 13409 f.
cheese (S. cŷse, cêse), 7329 f.
cheesĕ, 3628, suspicious verse: Wright, cheesĕ with, Tyr., chese and.
ende (S. ende, L. O. ende), 1867, 4901, 7037, 15 f, etc.
endĕ, 197.
hate (S. hete, L. hæte, O. hete), 6331 f, 13826 f, 16074 f.
hatĕ, 13640.
hegge (S. hege), 16704.
herde (S. hirde, O. hirde), 605, 12120.
hyve (S. hyfe, inc. gen.), 16878, 7275 f.
ire (S. yrre, inc. gen., O. irre), 1661, 1764, 7593, 17210, 17220.
irĕ, 7575: rh. squire (?), 7671.
leche (S. læce, lêce, L. læche), 3902 f, 7474 f, 7538 f, 11984 f, 14331 f.
lye (S. lyge), 3017 f, 3391 f, 5609 f, 12527 f, 13055 f.
mede (S. meadu), 89 f, 6443 f, 10105 f, 11459 f.
myre (S. mŷre), 510 f, 6554 f, 16937 f.
pilwe-beer (S. pyle), 696.
reye (S. ryge, Bosw.), 7328 f.
skathe (S. scæðþe, inc. gen., Bosw.), 448 f, 9048 f.
tete (S. tite, also tit), 3704 f.
whete (S. hwæte), 5725, 4312 f, 13863 f, 14278 f.

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come (S. cyme, L. cume, come, O. çome), 12271? "come and."
mere-mayd (S. mere, L. mere), 16756?
mete (S. mete, also mett, L. O. mete), 127, 15910 10932 f. But metĕ, 136, 345, 9795, 10384.
see (S. sæ, inc. gen., L. O. sæ), always monosyllable 278, 700, 4914, 4963 f, etc.

§ 8. Exceptions.

Termination -schipe* (S.-scipe).	felawschipĕ, 476. friendschipĕ (S. freôndscipe), 430. lordschipĕ (S. hlâfordscipe), 1627, rh. *felawschipe.* worschip (S. weorthscipe), 12560.
Termination -ere in Saxon nouns, signifying for the most part an agent.	carter, 7122, 7124, 7141. hopper (S. hoppere), 4034, 4037. loverĕ, 1381? mellere, 547? 4044? 544, rh. *mere*, 3167, rh. *forbere*: miller, 3923, 3993, 3998, 4008, 4094. outrydere (S. utrîdere, L. ridere), 166? sleper (S. slæpere), 16377. wonger (S. wangere), 15320 f, rh. *destrer*, Fr. *destrier*.

It is quite as likely as not that in the third and fourth cases cited the final e of *mellere* was pronounced. Concerning this doubtful **e** after **-r**, see further on, § 84.

§ 9. THIRD DECLENSION OF ANGLO-SAXON NOUNS. — Neuters. (III. 1.)

ale (S. ealu, ealo), 343, 669, 13736, 3130 f, 13730 f.
ancle (S. ancle), 1662.
mele (S. melu, O. mele), 4040, 3937 f, 4243 f.
 melĕ, 4051, 4068.
spere (S. spêre, L. spere, *sper*), 15289, 1641 f? 4879 f?
 sperĕ, 2712.
werre (S. werre, L. weorre, werre), 5972, 47 f, 1449 f: werrĕ, 1289.
wyte (S. wîte, O. wite), 12881 f.

§ 10. Masculines. (III. 2.)

lake (S. lacu, lagu, L. lake, *læc*), 5851 f, 16698 f.

§ 11. Feminines. (III. 3.)

breede (S. brædo), 2918, 1972 f, 13156 f, 15646 f.
care (S. cearu, L. O. care), 1491 f, 4934 f, 14611 f, 15170 f.

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stree (S. strea), 2920, 2935 f, ee (as before in *see*), pronounced as e: straw (from the other S. form straw), 11007.

* The length of the words compounded with this termination may perhaps account for the final e being soon dropped.

elde (S. yldo, also, yld, II. 3, L. ælde, *æld*, O. elde), 6789, 6797, 3883 f.
fare (S. faru, L. fare, fore), 1811 f, 4989 f.
gappe (S. geapu, Bosw.), 1641, 1647 f.
hele (S. hælo, L. hele, O. hæle), 1273 f, 3104 f, 13531 f.
hete (S. hæto, L. hate, O. hæte), 12448 f, 12506 f, 13336 f, 13453 f.
lawe (S. lagu, also, lag, II. 3, L. laȝe, lawe, O. laȝhe), 311, 4177, 4178, 7471, etc.
nave (S. nafu), 7848 f.
nose (S. nasu, nosu), 152, 559, 7846.
 nosĕ, 123, 2169.
sake (S. sacu, L. O. sake), 10039, 6945 f, 7299 f, 7314 f, 8131 f.
 sakĕ, 539, 1319, 1802.
sawe (S. sagu, L. saȝe), 1165 f, 1528 f, 6241 f, 12619 f.
schame (S. scamu, O. shame), 12433, 13335, 1557 f, 3052 f.
schonde (S. scandu, scondu, O. shande), 15316 f.
schadwe, shawe (S. sceadu, also II. 2), 4430, 4365 f, 6968 f: schadw*e* he, 4430.
scole (S. scôlu), 7768, 9443, 14909, 14915.
sowe (S. sugu), 2021, — bad line.
spade (S. spadu, also, spad, II. 3), 555 f.
tale (S. talu, L. O. tale), 36, 3128, 4466, 5545, 7253. (29 cases.)
 "talĕ yit," 13875, *e* elided before *y*?
trouthe (S. treôwðo, L. treouðe, O. trowwþe), 3502, 6595, 6633, 6986, etc. (16 cases.)
 trouthĕ, 10959, 11071, 11905: trouth, 10262: in all, 4 cases.
ware (S. waru, Bosw.), 4560 f, 14467 f.

§ 12. Exceptions.

III. 2. sonë (S. sunu, L. sune, sone, O. sune), 1965, 11000, 15669.
 But sonĕ, 6733, 7655, 8524, 8552, 12345, 15016, 15889, 16597, 17250, etc., etc.
woodë (S. wudu, L. wude, wode, O. wude), 110, 15181.

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dore (S. duru, also, dyr, II. 3, L. O. dure), 1989, 13065, 13145, 14624, etc.
 But dorĕ, 2424, 3471, 3482, 3634, etc.
highte (S. heâhðo), 2921 f: but 4432, rh. with *bright* (brighte?), 17298, rh. *right.*
mayne, meigne, contracted (S. menigeo, mengeo, O. mæne), 1260, 7627 f, 10310 f, 14459 f.

But woodĕ, 2932, 7755, 10727, 15742: wood, 1620.

III. 3. answar (S. andswaru, L. answare, O. anndsware), 6492.

lovë (S. lufu, also, lufe, I. 3, L. lufe, love, O. lufe), 260, 674, 6096, 6336, 14569. (5 cases.)

But lovĕ, 1137, 1756, 1807, 2226, 2262, 2308, 2316, etc., etc. (17 cases.)

§ 13. Many nouns which in Anglo-Saxon end in a consonant have in Chaucer the termination ë, derived from an oblique case of the old inflection.*

Two forms not infrequently occur; one with, and the other without, the vowel. By the dropping of this vowel in later English, the primitive form is restored. Though this secondary, transitional form in ë is found in Layamon and the Ormulum (quite frequently with Feminines of the second Saxon declension), yet it is by no means so common as in Chaucer.†

§ 14. MASCULINES AND NEUTERS OF THE SECOND AND THIRD DECLENSIONS. (II. 1, 2, III. 1, 2.)

bedde (S. bedd, *n.*, L. bed, dat. bedde, O. bed, o bedde), to, 4157, 4158, 12069; in, 9925, etc.
  bed, to, 4217 f; in, 4204 f; unto, 4256.
berne (S. bern, *n.*, L. bærne, O. berrne), on, 13812 f.
bissemare (S. bismer, *n.*, bisemar, bisemære), of, 3963 f.
bladde (S. blæd, *n.*), acc., 620 f.
borwe (S. borg, *m.*, L. borh), to, 10910 f.
botme (S. botm, *m.*), to, 13249.
brede (S. bread, *n.*, L. bred), of, 7422.
brembre (S. brêmber, *m.*), nom., 15157.
bronde (S. brond, m., L. brond), out of, 15313 f.

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arme (S. earm, *m.*), 158, probably an error; 2918, should be armes.
bore (S. bâr, *m.*), acc. 2072 f?

carte (S. cræt, *n.*, L. carte, O. karrte), nom. 7123; upon, 2043; in, 10107.
  cart, nom. 16522; acc. 7121, 7136, 16533.
childe (S. cild, *n.*, L. child, childe, O. child, wiþþ childe), nom. 5339, 14980, 15217 f; acc. 8459; with, 5140, etc.
  child, nom. 15221, 15228, 15241; acc. 8488, 15768.
corne (S. corn, *n.*, L. O. corn), in, 14404 f.
croppe (S. cropp, *m.*), in, 1534.
cultre (S. culter *n.* (?)), nom. 3761, 3783, 3810.
dale (S. dæl, *n.*, L. dal, dale, O. dale), over, 15248 f; [in, 16309 f.
donge (S. dung, *m.*), of, 16504.
  dong, of, 532, 16534.
drynke (S. drinc, *m.*, possibly also drinca, I. 2, L. drinc, drinke, O. drinnc, drinnke), acc. 1617, 3411, 4918, 7481, etc.
feere (S. fær, *m.*), for, 2346, 2688, 2932, 7286.
ferne (S. fearn, *n.*), of, 10569 f.
folde (S. falud, fald), acc. 514 f; in, 1310 f.
foote (S. fôt, *m.*, L. fot, dat. fote, O. fot, with fote), on, 10704 f; acc. 11489.
fyre, fuyre (S. fŷr, *n.*, L. fur, O. fir), on, 6553 f, 7564 f, 7704 f.
  fyr, nom. 2921, 2935, 2948; in, 2947; unto, 2952.
gate (S. geat, *n.*, L. ȝæt, dat. ȝæte, O. ȝate), nom. 14144 f; at, 7163 f.
golde (S. gold, *n.*, L. gold, dat. golde), with, 12138.
grave (S. græf, *n.*), in, 2780 f; to, 14080 f.
grounde (S. grund, *m.*, L. grund, grunde, O. grund, to grunde), to, 5573 f; under, 11581 f; unto, 15086 f; to, 16533 f.
grove (S. græf, *n.*), til, 1480; of, 1604; in, 2862; bisyde, 16309.
  grovĕ, to, 1690.
-hede (termination, S.-hâd: L. child-hode, man-ede, occur in later text, O. maȝȝdenn-had, maȝȝþ-had, but in L. and O. this termination is rare).
  bretherhede, with, 513.
  chapmanhede, in, 14649 f.
  childhede, in, 14912 f.
  falshede, on, 13101; for, 13202 f.
  manhede, of, 758; acc. 1287 f.

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cole (S. côl, *n.*, L. col, dat. cole), acc. 13088 f? nom. 13124? of 12737 f, rh. *vitriole*, Fr. vitriol.
derke (S. adj. dearc), in, 4336 f.
domĕ (S. dôm, *m.*, L. dom, dat. dome, O. dom), to, 11240.
fisshe (S. fisc, *m.*, L. fisc, fisce), to, 180, bad line.

* A few familiar parallel formations in other modern languages may be mentioned. *Lat.* radix, *Ital.* radice; animal, animale; cupido, cupidine; imago, immagine; nix, neve; latro, ladrone; honor, onore; libertas, libertate; voluptas, voluttate. So in colloquial Romaic, as compared with Greek:— *Greek*, λαμπάς, *Romaic*, λαμπάδα; χήν, χῆνα; νύξ, νύκτα.

† As it is possible that some may think the forms in ë of the Masculine and Neuter nouns to be oblique cases of a nominative, which (if it occurred) would be found to end in a consonant, the grammatical relations of these nouns are always indicated, but this (probably superfluous) trouble has not been taken with the Feminines.

maydenhede, nom. 4450 f; acc. 5651 f, 8713 f, 8742 f, 12054 f, etc.
wommanhede, acc. 8951 f; of, 13274 f.
brotherhed, of, 14453; maydenhodĕ, acc. 2331; humblehedĕ, fro, 16158?
heede (S. heafud, *n.*, L. hæfd, hæfde, O. hæfedd), for, 1056 f; upon, 14158 f.
heed, sauf, 10404; heved, acc. 12294.
herne (S. ern, *n.*), in, 11433 f.
hevene (S. heofon, *m.*, L. heovene, O. heoffne, heffne), of, 7588 f, 13400 f; in, 9513 f.
hewe (S. hiw, L. heowe, O. hew, inn hewe), nom. 1366; of, 460 f, 1040 f, 4557 f.
hew, of, 1649 f.
hole (S. hol, *n.*, L. hol, dat. hole), in, 13209.
-holme, Bromholme (S. holm, *m.*, L. dat. holme), of, 4284 f.
house (S. hûs, *n.*, L. hus, dat. huse, O. hus, inn huse), in, 5934.
kynne (S. cynn, *n.*, L. cun, dat. cunne, O. kinn), by, 4036 f, 16969 f.
leeke (S. leâc, *m.*), 12723 f.
leek, nom. 3877.
liche (S. lîc, *n.*, L. O. lic, lich, dat. liche), nom. 2960.
londe (S. land, lond, L. lond, dat. londe, O. land, to lande), to, 4942 f; unto, 12878 f; in, 15295 f; on, 16365 f.
loode (S. hlæd), nom. 2920 f.
loone (S. læn, *n.*, L. læn), of, 7443 f, 14706 f.
lyste (S. list, *m.*), in, 1715; acc. 1864.
lyve (S. lîf, *n.*, L. lif, dat. live, O. lif), acc. 9111 f; on, 2700 f, 3041 f, 5625 f.
lif, acc. 1174 f; during, 5740 f; by, 9320 f.
{ morne (S. morgen, morn, *m.*, L. morȝen, morȝe, morwe), nom. 360, 3236; morwen 10099.
morwe, nom. 832, 14710; acc. 1494.
mynde (S. mynd, *n.*, also II. 3, O. mìnde), nom. 13347; acc. 4947; in, 4846 f; of, 15005f, etc.
othe (S. âð, *m.*, L. að, oað, dat. oðe), nom. 1141.
acc. oth, 3291? ooth, 120, should probably be oothë.

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keepe (S. ?), acc. 8934; but keep, 400 f, 10272 f, etc.; kepĕ, 6207; at 505 f should certainly be *keep.*
mele (S. mæl, *n.*, L. mæl, mele), acc. 4886; but mel, meel, 7356 f, 16319 f.
schepe (S. scæp, *n.*, O. shep), nom. 506 f, should certainly be scheep: cf. 6014, 13766, where the same rhyme occurs, 508, 16317.

schippe (S. scip, *n.*, L. scip, schip, dat. scipe, shipe), schip, in, 5032. [in, 4859.
sithe (S. sîð, *m.*, L. sið, dat. siðe, O. siþe), acc. sing.? 9183, 5153 f, 5575 f.
sleepe (S. slæp, *m.*, L. dat. slæpe, O. slæp, slæpe), of, 1046; in, 16498.
sleep, in, 16420; for, 16283 f.
smoke (S. smêc, *m.*, also I. 2, O. smec) nom. 5860 f; with, 2002 f.
sore (S. sâr, *n.*, L. sar, sor, dat. sare, sore), nom. 2745 f; of, 2851 f.
sothe (S. sôð, *n.*, L. soð, soðe, O. soþ, to soþe), acc. 12590 (rh. *to the*, but perhaps adverb), 6183 f; for, 12095 f.
spelle (S. spell, *n.*, L. spel, dat. spelle, O. spell), to, 15301 f.
stalle (S. steall, *n.*, O. stall), unto, 8083 f; in, 16482 f, 16490 f, 16513 f.
style (S. stigel, *m.*), over, 10420 f, 14126 f.
swyne (S. swîn, *n.*, L. swin, dat. swine, O. swin), nom. 16972; swyn, nom. 13971 f.
temple (S. tempel, *n.*), toward, 13534.
tothe (S. tôð, *m.*, O. toþþ), acc. 6184 f.
towne (S. tûn, *m.*, L. tun, dat. tune, O. tun, to tune), of, 568 f, 7153 f; at, 7876 f; in, 15204 f.
toun, acc. 7936, 11713 f; unto, 896 f; in, 14732 f.
wawe (S. wæg, *m.*), nom. 4888.
wedde (S. wedd, *n.*, L. dat. wedde), to, 1220 f, 14834 f.
werke (S. weorc, *n.*, L. wærc, dat. wærce, O. weorrc, werrc), on, 5797; for, 13439; of, 11191 f.
werk of, 11418 f.
weye (S. weg, *m.*, L. weie, wai, O. weȝȝe), acc. 793 f, 4805 f; by, 773 f; atte, 1124 f.
contracted, way, 7118, 14176 f.
whelpe (S. hwelp, *m.*, O. whellp), nom. 259 f.
whippe (S. hweop, *m.*), nom. 5757 f, 9545 f.
wife (S. wîf, *n.*, L. wif, wive, O. wif, to wife), nom. 6648; to, 1862 f.
wronge (S. wrang, wrong, *m.*?), on, 11096.

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sighhe (as if from S. sîc), with, 10811 f.
swoune (as if from S. swûn), on, 13668.
teere (S. tear, *m.*) with, 4957 f, 15664 f; acc. 15547 f, 16148 f. (?)
walle (S. weall, *m.*, L. wal, dat. walle), upon, 1970 f; 1911, rh. *coralle*, which should be coral (O. Fr. *coral*).
wallĕ, 1990, wal, 1921, 1977, 1936 f.
wyne (S. wîn, *n.*, L. win, dat. wine, O. win), nom. 10016 f.
wyn, acc. 637, 14212, 639 f; of, 336 f, 2910 f, etc.

yere (S. gear, *n.*, L. ʒer, dat. ʒere, O. ʒer), acc. 4552 f; by, 14909 f, 15545 f, etc.
yer by yere, 8278 f, 14909 f; yer, yeer, 1035, 1445, 1731 f, 8487 f, etc.

§ 15. The following merely drop a final *n* (compare Lat. and Ital. acumen, acume; certamen, certame; vimen, vime).

eve (S. æfen, *m.*, L. aefen, heve, O. efenn), nom. 832, 4993 f; at, 5914 f.

game (S. gamen, *n.*, L. gamen, gome, game), nom. 3405, 14701 f; acc. 855 f; in, 14244 f.
gamĕ, nom. 2288, 3741.

mayde (S. mægden, maeden, *n.*, L. maiden, maide, O. maʒʒdenn), nom. 8253, 12055, 14878; acc. 6468, etc.
mayden occurs 3202: before *a*, 2307, 6469; 2310?

§ 16. Feminines of the Second Declension. (II. 3.)

These nouns have in Anglo-Saxon all the oblique cases of the singular in ĕ.

beere (S. bær, L. O. bære), 15036, 15038 f, 2879 f.
bene (S. beân), 9296, 3770 f, 4514 f, 9139 f.
boone (S. bên, O. bene), 2271 f, 2671 f, 9492 f, 12162 f, etc.
boote (S. bôt, L. O. bote), 426 f, 6054 f.
brigge (S. brycg, L. brugge), 3920 f.
bryde (S. brŷd, L. brude, O. brid), 9764.
bruyd, 9694.
burthe (S. beorth), 4612, 8278, 5982 f.
bynne (S. binn), 595 f.
dede (S. dæd, L. dede, O. daed), 661 f, 744 f, 4853 f, 5311 f, etc., etc.
doune (S. dûn, O. dun), 15207 f.
drede (S. dræd, L. dred, drede), 16648, 8010 f, 9031 f, 12132 f, etc.
fille (S. fyll), 1530 f, 7282 f.
gifte (S. gift, L. ʒeft), 9185, 5685 f, 12203 f.
gleede (S. glêd, also masc.), 1999 f, 3379 f, 4531 f, 15870 f.
halle (S. heall, L. halle), 10394, 11457, 9764 f, 16370 f, etc.
hallĕ, 10400.

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asp (S. æsp, according to Bosw. *masc.*), asp' aldir, 2923?
booke (S. bôc, III. 3, L. O. boc) occurs once, 6373. book, 6251, but book[e], 6232?
droughthe (S. drugâth, fem.?), 10432.

heede (S. hŷd), 305 f, 8511 f, 10926 f, 12363 f, 13178 f.
heed, 7483, 12987.
helle (S. hell, L. O. helle), 7042, 7218, 11204, 12846, etc.
hellĕ, 660?
helpe (S. help, O. hellpe), 9202, 260 f.
helpĕ, 10773, help, 11983.
heste (S. hæs, L. heste, O. hæse), 3588, 16050, 4457 f, 4802 f.
hest, 11376, 8004 f?
hyre, huyre (S. hŷr, L. hure), 6590 f, 7555 f, 16938 f.
keye (S. cæg), 9918 f, 13147 f.
kynde, man-kynde (S. cynd, L. cunde, O. kinde), 1309, 3521, 6298, 7225, 10924, etc. (16 cases.)
kyndĕ, 11080, 5263.
lengthe (S. lengð), 17302, 83 f.
leve (S. leâf, L. O. lefe), 4005, 6490, 7395, 13653, 5665 f, 7071 f, 7395 f, etc.
levĕ, 5694, 9715, 14263.
lisse (S. lîss), 11550 f.
loode-sterre (S. lâd, also lâdu, O. lade), 2061.
lore (S. lâr, L. O. lare), 4762 f, 16456 f.
lydne (S. læden, lŷden), 10749, 10792.
lyvere (S. lifer, L. livere), 7421 f.
meede (S. mêd, L. O. mede), 772 f, 3380 f, 8761 f, 13548 f.
melle (S. mylen), 3921 f, 4240 f.
myllĕ, 4019: millen occurs, 4309.
merke (S. mearc, L. marke, O. merrke), 11192 f.
merthe (S. mehrð, L. murthe), 768, 14786, 5981 f.
mirthĕ, 9613.
myle (S. mîl, L. O. mile), 12816, 14687, 14127 f.
mylĕ, 14102.
neede (S. neâd, L. neod, neode, O. ned), 306 f, 4532 f, 4924 f, 13179 f, 15872 f.
-nesse (termination, S. nes, nis, L. O. uniformly nesse).

besynesse, 14636, 6778 f.	hevynesse, 5565 f.
boldënesse, 13486.	holinesse, 9582 f.
brightnesse, 12089 f.	homlynesse, 8305 f.
clennesse, 12088 f.	lewednesse, 15329f.
cursednesse, 13815 f.	newëfangilnesse, 10923 f.
drunkennesse, 5196.	schamfastnesse, 842 f.
fairnesse, 521 f.	seeknesse, 1258 f.
falsnesse, 12904 f.	sikernesse, 9229 f.
goodnesse, 17254 f.	stedfastnesse, 9937 f.
hardynesse, 1927 f.	warmnesse, 10095 f.
hethenesse, 49 f.	wikkednesse, 5043 f.

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lynde (S. lind), 9087 f: but lyndĕ, 2924.

witnesse, 13898 f.
worthinesse, 50 f.
wrecchednesse, 13965 f.
ydelnesse, 11930 f.
etc., etc.

But, besynes, 13140.
clennessĕ, 508?
goodnes, 7395.
lewednes, 10537, 12415.
lustynes, 1941 f?
worthines, 2594.
woodnes, 2013, 13911, should be woodnesse.

ore (S. âr, L. are, ore, O. are), 3724 f.
plyte (S. pliht, L. pliht, plihte, O. plihht), 12880 f.
pyne (S. pîn, also, masc., L. O. pine), 5500 f, 5967 f, 6369 f, 15344 f.
querne (S. cweorn), 15560.
rewe (S. râw), 2868 f.
roode (S. rôd, L. O. rode), 6078.
schipne (S. scypen), 2002.
sleeve (S. slêf), 13152 f.
slouthe (S. slewð), 4950 f, 12186 f,
sonde (S. sand, L. sonde), 4809 f, 4943 f, 5246 f, 5469 f, etc.
sorwe (S. sorh, L. sorhȝe, O. serrȝhe), 953, 1221, 1279, 9956, etc.
soule (S. sâwel, L. saule, O. sawle), 783, 1865, 2788, 2794, 8435, etc. (13 cases.)
soulĕ, 658, 14355, 14399.
spanne (S. spann), 155.
speche (S. spæc, L. O. spæche), 519, 1373, 2800, 17270, etc.
spechĕ, 16978.
stounde (S. stund, L. stunde, O. stunnd), 3990 f, 5441 f, 1214 f.
streete (S. stræt, L. stræt, stræte, O. stræte), 14904, 15025, 4382 f, 11806 f, etc.
strengthe (S. strengð, also -u, L. strengþe, O. strenncþe), 1950, 2401, 2403, 15550.
synne (S. synn, L. acc. sunne, O. sinne), 5010, 6773, 9713, 13701, etc.

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rewthe, routhe (as if from S. hreôwð, L. rouðe), 916, 8438, 11661, 14608 f, etc.: rewthĕ, 10752.
scherte, schurte (as if from S. sceort, scyrt), 15608: 1568, 9859 (rh. *herte*); schert, 6768 (rh. *povert*); 9726, 9757, 16606 (rh. *hert*, doubtful).
sleighte (S. slîð, from sliðan, to slide?), 4009, 7013; 13546 f? but sleight, 1950.
stevene (S. stefn, L. stefne, O. steffne), 4381, 1526 f. steven (rh. *heven*), 2564, 10464, 16683, 16777, (all doubtful.)

throwe (S. þrag, also -u, L. þrowe, O. þraȝhe), 5373 f, 7397 f, 12869 f, 15622 f.
tyde (S. tîd, O. tid), 4930 f, 5554 f, 10456 f, 16502 f.
tyle (S. tigel), 7687.
upriste (S. uparist, O. ærist), 1053 f.
wede (S. wæd, L. wede, O. wæde), 1008 f, 8739 f, [15325 f.
werte (S. weart), 557.
while (S. hwîl, L. while, O. whil, i-while), 4226, 8899, 10904, 7027 f, etc.
wolle (S. wull, O. wulle), 13863, 14325 f.
wombe (S. wamb, womb, L. wombe, O. wambe), 7470, 15923, 15970.
wounde (S. wund, L. wunde), 1012 f.
yerde (S. gerd, geard, L. ȝerd, O. ȝerrde), 149, 1052, 14508, 7898 f.
youthe (S. geogôð, L. ȝuȝeþe), 2381, 4583, 7996, 14139, etc.

§ 17. Exceptions.

aldir (S. alor, alr), 2923.
ax (S. æx, eax, L. æx, O. axe), 2546, 3569.
bench (S. benc, L. benche, O. bennche), 5829, 14769.
bliss (S. bliss, L. O. blisse), 1686, 4829, 6412, 16644 (all rh. *this*); 4453, 16652 (rh. *is*); 16686 (rh. *i-wis*); 4842.
blissë, 1451, 3104, 9504, 11856, 6835 f, 7439 f, [10049 f, 11549 f.
box (S. box), 5165.
chest (S. cest, cist), cist), 6084, 7905, 14149 (rh. *rest*); 5899, 6982 (rh. *lest*, pres. indic.).
curs (S. curs), 663; 658 (rh. *purs* (?)); 4347 (rh. *the wors* (?)).
fann (S. fann, *inc. gen.*), 3315, 16974 (rh. *man*). (?)
fist, fest (S. fŷst), 6374; 4273 (rh. *brest*); 6216 (rh. *list*); 14217 (rh. *best*); 17329 (rh. *lest*).
fitt (S. fitt), 4182, 4228, 5624 (rh. *wit*).
flight (S. flyht, L. fluht, fliht, O. flihht), 990 (rh. *knight*); 1694 (rh. *right*).
floor (S. flôr, L. O. flor), 3471.
hand* (S. hand, hond, L. hand, hond, dat. honde, O. hand, wiþþ hande), 785, 2349, 3084, 5814, 6591, 14112, 15717, 15802, 193 f, 1605 f, 1932 f.
hand / fand } 4113. hond / fond } 5026. hond / bond } 10065.

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wilw (S. wilig), 2924, doubtful: "wilw, elm," etc.
wreche (S. wræc, also -u, L. wreche, O. wræche), 5099: but wrechĕ, 16089.

* Hand, miht, niht, wiht, weorold have all of them the accus. sing. like the nom. in Saxon, instead of forming it in -e, according to rule.

hondë, handë, 13788, 4033 f, 5808 f, 5909 f, 5962 f, 5975 f, 6033 f, 7648 f, 11941 f, 12130 f, 15149 f, 15405 f.
heeth (S. hæð), 6 f, 608 f, 3262 f.
hen (S. henn), 178, 6694, 16925 (all rh. *men*).
mark (S. marc), 12954.
might * (S. miht, meaht, L. mihte, O. mihht, mihhte), 1789, 2237, 2382, 4882, 7069, 12183, 12365, 14703:—962, 1152, 1609, 1858, 2114, 3080, 10624, 11914 (all rh. *knight*):—539, 1878 (rh. *wight*), etc., etc.
mightë, 10447 ?
milk (S. milc, meolc, L. milc, O. millc), 360, 3236, 10928 (all rh. *silk*).
night * (S. niht, L. niht, dat. nihte, O. nihht), 10, 23, 1475, 1478, 9672:—1044, 16013 (rh. *dight*), etc.
nightë, 16704: 12476 f, extremely doubtful.
ok, ook (S. âc), 2292, 2923, 14180, 1704 f.
queen (S. cwên, L. quen, quene, O. cwen), 1821, 6443, 6481, 6598, 15199, 15201, 15210, 15839, etc.
queenë, 15834, 973 f, 4581 f, 4812 f, 6630 f, 10110 f, 11358 f, 13017 f, 14892 f, 15834 f, etc.
sight (S. sihð, L. siht, dat. sihte, O. sihhþe), 10657, 11470:—3395, 11225 (rh. *light*): 7653, 10134 (rh. *knight*): 8118 (rh. *aright*), etc.
sightë, 2118, 2335, 3949, 8075, 10280.
rest (S. rest, O. resste), 5161, 8036 (rh. *lest*, pres. tense): 6083, 7906 (rh. *chest*): 7077, 9736, 10669 (rh. *for the best*): 9005 (rh. *the worthiest*): 14759 (rh. *his best*): 8595 f? 6686 f?
restë, 822, 9729:—8617, 10920, 11548 (rh. *leste*, imperf.): 8722 f? 9678 f? 10693 f?
soken (S. sôcen), 3985.
tow (S. tow), 5671.
wight * (S. wiht, wuht, L. wiht, whit, O. wihht), 1427, 2108, 2487, 9504, 11091, etc., etc.
world * (S. weorold, L. weorld, weorlde, O. weorelld), 176, 187, 414, 1267, 1306, 1326, 1362, 2589, 9667, 11091. etc.
worldë, 16151, 10376 ?
-yng, termination (S. ung, ing).

Nouns derived from Saxon feminine nouns in -ung, -ing, or formed in imitation of such, terminate in Layamon mostly in -ingë, rarely in -ing. In the Ormulum the termination is almost invariably -inng, but one or two have the nominative, and three or four an accusative, in -inngë. The more usual ending in Chaucer is certainly -yng. The termination -ynge occurs frequently at the end of a verse, and in most cases rhymed with an infinitive.

* See note on preceding page.

àxyng (S. ascung), 1828.
begynnỳng, 3009 (rh. *thing*).
clòthing, 8132.
comỳng (S. cuming), 14461 (rh. *thing*).
cònnyng (S. cunning), 5519.
dwellỳng, 6992 (rh. *thing*).
fightỳng (S. fihtung), 1658.
hàngyng, 2460.
hàrpyng (S. hearpung), 268.
hùntyng (S. huntung), 191, 1689.
lòkyng (S. lôcung), 2173, 3591.
longỳng (S. langung), 3679.
makỳng (S. macung), 449.
offrỳng (S. offrung, Bosw.), 452.
rènnyng (S. rinnung), 553.
smỳlyng, 119.
tèching (S. tæcung), 520.
wàndryng, 469.
wèpyng, 2831.
wònyng (S. wunung), 608.
writỳng (S. writung), 328 (rh. *thing*).
wynnỳng, 277 (rh. *thing*).

But lernỳnge (S. leornung), 12281.
turneỳnge, 2559.
vanysschỳnge, 2362 (rh. plur. pres. indic.).
walkỳnge, 10722.

So carolỳnge, 13273.
connỳnge (S. cunning), 15068.
dawenỳnge (S. dagung), 4232, 16368.
envenymỳnge, 9934.
felỳnge, 16779.
lyvỳnge, 14262.
morwenỳnge, 16788.
offrỳnge, 6897.
rejoysỳnge, 17178.
semỳnge, 15059.
tarỳinge, 823.
werkỳnge, 13043.

all rhymed with infinitives, synge, brynge, stynge, sprynge, etc., etc., etc.

§ 18. The following nouns, of etymons more or less uncertain, but mostly of undoubted Gothic origin, are found in Chaucer terminating in -ĕ.

brinke (*Icel.* bringr = colliculus), 11472, 9275 f, 11170 f.
cake (*Dan.* kage, *Swed.* kaka), 4309 f, 13737 f.
chaffare, 14696 f, 14751 f.
cloke (*M. Lat.* cloca, *Flem.* klocke), 2001 f.
clowde, 16268 f.
cope, 15435 f.
daggere (a thing to dag, or pierce, with, Sax. ending -ere?), 14070, 113 f; dagger, 14245.
deynté (*Welsh* dant = tooth; dantaidd, toothsome, Wedgewood), 4559, 5790, 9917.
dogge (*Icel.* doggr, *Dutch* dogghe), 6951, 9888.
drake, 3576 f.
felàwë, 2550, 16512, 397 f, 655 f, 1527 f, 4248 f, 4366 f, 6967 f, 16499 f.
  fèlaw, 650, 1194, 2626, 2657, 4257, 7605, 7624, 7668, 16489, 16514, 16516, 16527, 16531.
  felàwĕ, 652, fèlawĕ, 892.
gable (*Goth.* gibla, *Germ.* giebel, *Dan.* gavl), 3571 f.
jade, 16298 f.
knarre, 551 f.
know-leche, 14441. (Can the termination -leche be the same as -leȝȝc in the Ormulum = there, to -ness?)
kyn-rede, 1288 f, 11047 f.
marle (*Germ.* mergel, *Lat.* marga, *Fr.* marne), 3460.
rote, roote (*Icel.* rôt, *Goth.* vaurts), 13389, 2 f, 329 f, 425 f.
sculle (*Old Germ.* sciulla, *Ang.-Sax.* scell?), 3933 f, 4305 f.
slynge (as if from *Ang.-Sax.* sling), 15240 f.
snowte (*Dan.* snude, *Swed.* snyte), 14816 f; snowt, 16391.
stalke (*Icel.* stilkr, *Swed.* stjelk), 3917 f.
tare, 1572 f.
wyndòwe (*Icel.* vindauga, *Dan.* vindue, *Swed.* vindöga), 3358 f, 3676 f, 3695 f.
  wỳndŏw [e?], 3708, 3725, 3730, 3738.

§ 19. The unaccented final e of nouns of French origin is sounded in Chaucer, as it is in French verse. Exceptions, however, are frequent.

Arcìte, 1579, 1582, etc.	Arcìtĕ, 1147, 1357, 2317.
aunte, 5401.	
	best, 7424, 9413, 10578, [6616 f.
bille, 13585, 13591 f.	
cause, 4142, 5705, 7056.	
centre, 10336.	
chambre, 1073.	chambrĕ, 9696.
couche, 7351.	
cynamome, 3699.	
dame, madame, 15382, 16444, 16686.	ma-damĕ, 11635, 11830, 16456.
doute, 9959.	
Dyàne, 2074, 2348, etc.	Dyànĕ, 2293.
eese, 971.	
egle, 2180, 10437.	
entente, 1489, 7138, 14986, 7212 f, 8610 f, 8737, 11934 f, etc.	entent, 3173, 4567, 13234, 5350 f, 15123 f.
experience, 7099 f.	experiens,* 10112.
face, 1580, 16252.	faas,* 13117 f!
feste, 908, 6660, 8067, 8072, 8145, 8886.	fest, 6658.
force, 3910.	forcĕ, 3910; fors,* 7771, 9171, 9709, 10214, 10304, 13548, 13718 f.
fortune, 15487, 15727, 15943, 16209.	
grace, 16219, 3071 f, 14132 f.	gracĕ, 1175, 6842; gras,* 15242!
haunche, 3279.	
herbe, 11344.	
heritage, 10046, 11867.	
homicide, 14978.	
hoste, oste, 753, 6868, 16936.	host, ost, 829, 3116, 12591, 12625; 11007, 12580, rh. *wost;* 16988, rh. *gost.*
joye, 1873, 1875, 12507.	
juge, jugge, 12317, 12391, 13540, 13573.	
male, 12494.	
manere, 10501 f, 11737 f.	maner, 10452, 11742, [11745.
medecine, 10254.	
nece, 14511, 14536, 14744.	
persòne, 15428.	persòn, 10339.
peyre, 4384.	
	phisik, 413, 2762.
place, 7262, 9963.	placĕ, 15024.
plante, 11344.	
pompe, 8804.	
regne, 4813.	regnĕ, 1626.
remembraunce, 9855.	
requeste, 8061 f.	request, 7980 f.
Rome, 673 f, 4576, 5388, 10545, etc.	Romĕ, 5386.
sauce, 129, 353.	
sege, 939.	
servise, 122.	
signe, 10024, 10087.	

* For other similar cases, see further on, § 91, *f.*

spouse, 12072, 12125.
tente, 16055.
trumpe, 2176, etc., etc.

So with adjectives: —
chaste, 2306.
excellente, 10459.
nice, 12421, 12770, 12575 f.
pore, 480, 16307.
riche, 866, 1913, 4814.
solempne, 209, etc., etc.*

§ 20. The accented final **e** of French nouns (in modern English, y) is of course preserved in Chaucer.

adversité, 16639.	liberté, 9158.
bounté, 6742.	perré, 15791.
cherté, 11193.	plenté, 14226.
clarré, 1473.	pryvyté, 1413,
contré, 1006, 1215.	renomé, 6741.

§ 21. The Genitive Case, Singular, ends in **-ës**.

schires, 15.	lordes, 47.	pigges, 702.
cherles, 7788.	Cristes, 480.	reeves, 601.

But soth it is, right at his *modrës* heste,
Byforn hem allĕ, duryng the *metës* space,
The child stood lokyng in the *kyngës* face.
5433 – 5.

The following have, at least sometimes, no termination.

Dec. I. holy chirche good, 3981.	But, holy cherches feith, 11445.
holy chirche blood, 3982.	
his lady grace, 88.	his ladys grace, 9892.

Dec. I. oure lady veyl, 697.
the sonne upriste, 1053.
the sonne stremes, 16240.
myn herte blood, 10221.
a widow sone, 14913.

So, fader, brothir, doughter (as in Saxon).

fader benesoun, 9239.	But, fadres folk, 5883.
fader day, 9012, 15670.	fadres place, 8738.
fader hous, 8772.	fadres hous, 8685, 8747.
fader kynne, 4036, 9389, 12757, etc.	fadres pité, 13626.
fader soule, 15423.	fadres soule, 783?
	fadres sake, 10175?
	fadres sapience, 14883?
brothir sone, 3086, 15889.	brothers bedde, 11478.
brother knowleching, 13360?	
doughter name, 8485.	
	So, modres pité, 15004.

So, the philosophre stoon, 12790.
heven king, 6763, 10281, 12470, 16282.
heven queene, 13017.

So, many proper nouns in s, as in Anglo-Saxon and Modern English.
Epicurius owne sone, 338.
Peneus doughter, 2066.
Venus children, 10586.
Melibeus wyf, 15382.
Phebus wyf, 17170.

And also, the marquys governaunce, 8870.

§ 22. Plural of Nouns. Nominative.

The Nominative Plural is formed for the most part in **-ës**.†

ladiës, 900.	fowlës, 9.	croppës, 7.	lokkës, 76.	bootës, 203.
bodyës, 1007.	domes, 325.	robes, 319.	songes, 95.	argumentes, 4632.
kneës, 1105, 1877.	chiknes, 382.	knobbes, 635.	braunches, 1069.	ornamentes, 8134.
degreës, 17298.	bones, 702.	wyfes, 234, 15507.		houndes, 146.
	fyngres, 129.	knyfes, 368.		swerdes, 2028.
		kaytyves, 1719.		
		leeves, 1498.		

And with his *stremës* dryeth in the *grevës*
The silver *dropës* hongyng on the *leevës*. 1497, 8.

His lymës greet[*e*], his *brawnës* hard[*e*] and strongë,
His *schuldrës* brood[*e*], his *armës* rounde and longë. 2137, 8.

* It is scarcely necessary to mention that an internal e in French words is also pronounced, as, comaundëment, 2871, 2981, 12991; juggëment, 780, 820; etc., etc.

† Occasionally in -us or -is, a dialectic variety; as, leggus, 593; othus, 812; lordus, 830; argumentis, 9493; bestis, 16367; etc.

-s (*z*) only is frequently added, especially to nouns terminating in a liquid.

pilgryms, 2850.	sessions, 357.	achatours, 510.
naciouns, 53.	pens, 7158.	pilours, 1009.
bargayns, 284.	lazars, 245.	lovers, 1533.
sesouns, 349.	sellers, 248.	

So the following, of various terminations in the singular, in some of which, though -es is added, only s is sounded.

schoos, 459.	bisschops, 4673.	reliks, 13764.	servantes, 101.	greyhoundes, 190.
dys, 1240.	keverchefs, 455.	lordyngs, lordynges, 7250, 15725.	contractes, 6890.	stiwardes, 581.
	caytifs, 926.	yeddynges, 237.	vestimentz, 2950.	husbonds, 2825.
		prechings, 6139.	marchauntz, 4568, 4591.	
			arguments, 4648.	
			maundementz, 6866.	
			instrumentz, 9587.	

§ 23. The following have **-en, -n,** derived from the Saxon plural in -an of the 1st Declension.

asschen (S. ascan), 1304, 1366.
aissches, 12735.
assen (S. assan), 5867.
been (S. beôn), 10518.
bees, 7275, 10296 f, 16878.
eyen, yën (S. eâgan), 152, 16786.
fleen (S. fleân), 16949.
hosen (S. hosan), 458, 3953, 15144.
oxen (S. oxan), 5867, 16483.
schoon (S. sceôn, also sceos), 15143.
schoos, 459.
ton (S. tân), 16348, 16666, 16793.
toos, 16817.

§ 24. The following have **-n, -en,** by imitation, being of various declensions in Saxon.

bretheren (S. brôthru, L. brothere, brethren, brotheres; O, brethre), 13831, 14192.
doughteren (S. dôhtru, L. dohtere, dohtren, dohtres), 11741; doughtres, 16315.
sistren (S. sweostru, L. sustren, sostres), 1021.
sustres, 16353.
children (S. cildru, cilde, cild, L. childere, children, childres, O. chilldre), 1195, 14908.
childre, iii. 84; childer, 8031, 14912.
foon (S. fâ, Bosw.), 16192 f.
foos, 15815; ii. 323.
kyn (S. cŷ), 16317.

§ 25. The following have *no* termination in the plural, according to the rule of Saxon neuters of the Second Declension.

deer (S. deor), 15147 f (misspelt dere, 11502 f).
folk (S. folc), ii. 326; iii. 151.
folkes! 12102, 13020, ii. 329; 13879?
good (S. gôd), 583, 613, 13217, 14654, 14843.
hors* (S. hors, L. hors, horses), 600, 7129, 7141, 15044; 15590 (?); so 5867, Tyrwh.; horses, iii. 117.
neet (S. neât), 599 (where Wright reads "meet").
scheep (S. scæp), 599.
swin (S. swîn), 600.
thing (S. thing, L. thing, thinges), 12468 f, 16039.
thinges, 6166, 9805, 13853.
yer, yeer (S. gear, gêr), 3223, 8612, 8656, 9291, etc.
yeres, yeeres, 2969 f, 7531 f.

So night (fem. of 2d Decl.), 7467 f, "fourty dayes and fourty night," 16359, etc., like the Saxon *niht;* and wynter, "twenty wynter," 10357, 15545, etc., as also in Saxon; though both ought rather to be explained by a principle of syntax; see further on, § 100 *c*. Freend, 3052, 3053, is probably a plural (S. frŷnd, freônd, freôndas, L. freond, freondes, O. freond).

§ 26. The plurals formed by change of vowel are the same in Chaucer as in English.

feet (S. fêt), 1761; but feetë! 5524 f, "falleth him to feete."
gees (S. gês), 16877.
men (S. men), 178 f.
teeth (S. têð), 7743.

* So, in excellent MSS., at v. 74, "his hors *weren* gode."

§ 27. The following plurals of French words are remarkable.

caas, 325, 13578, iii. 84.
paas, 1892, 4726.
degré, 1892.
secré, 6923 (?).
orgon, 16337 f.
vessel, 15634; 15712, 15714 (?). But vessealx, vesseals, 15680, 15687.
richesses, ii. 368, 370, 371, iii. 92; sing. richesse, ii. 367; pl. riches, ii. 368.

§ 28. Genitive Plural. — The Genitive Plural in Chaucer is much the same as in English, saving, of course, the use of **ës** instead of **s**.

lordës hestës, 8405.
lordës doughtrës, 13488, 13491.
foxes tailes, 15519.
bestes dennes, 15749.
seintes lyves, 6272.
folkes wyves, iii. 167.
mennes wittes, 4622; soules, 7402.
wymmens counseiles, 16742.
his eyghen sight occurs, 10134.

ADJECTIVES.

§ 29. Adjectives which end in **e** in Saxon preserve the **e** in Chaucer.

blithe (S. blîþe, L. O. bliðe), 1880 f, 14210 f.
blithĕ, 848; blith, 10652.
clene (S. clæne, L. clæne, O. clene), 506, 12087, 14288.
clenĕ, 12228.
dere (S. deôre, L. deore, dure, O. deore, dere), 13593 f, 14921 f.
derne (S. derne, L. derne, O. dærne), 3200, 3278.
drye (S. dryge, dry, O. driȝȝe), 16334, 422 f, 15703 f.
elenge (S. ellende = peregrinus, and therefore miser, as in other languages (see Diefenbach, i. 37), d being changed to g, as in the modern English form of the present participle?), 14633 f, 6781 f.
fremde (S. fremede), 10743.
grene (S. grêne, L. grene), 2937, 3876.
heende (S. ge-hende (?), L. hende), 3199, 3401, 3487.
kene (S. cêne, L. O. kene), 2878 f, 9633 f, 15745 f.
kynde (S. cynde), 649 f, 8728 f, 15008 f.
lene (S. læne), 9727 f, 16299 f.
newe (S. niwe, L. niwe), 430, 8881.
proude (S. prŷte, prût), 7809.
prowd, 3863, 3167 (?).
ripe (S. rîpe), 17015.
scheene (S. scêne, L. scene, O. shene), 115 f, 1511 f.
softe (S. sôfte, sôft, L. softe, O. soffte), 6994.
stille (S. L. stille, O. stille, still), 10810 f, 11782 f, 16929 f.
sterne (S. L. sterne, O. stirne), 8341.
swete, swote (S. swête, O. swet), 2429, 5967, 6041, 15344.
thenne (S. þynne), 4064 f, 9556 f.
thikke (S. þicce, L. þicke), 551.
trewe (S. treôwe, L. treowe, O. trowwe), 533, 961.
un-weelde (S. un-vylde = impotens), 16987; 3884 also, but plural.
white (S. hwîte, hwît, L. white, whit), 4775. The common form is *whit*, 17065, 238, 3238, 2180 f.

Several other adjectives might probably be inserted in this list, but as they are found in the Canterbury Tales only in the "definite form" (see § 32), they have not been noticed.

(all-) oone, is from the S. definite form âna = solus, 9200, 9435, 14256 f, 14707 f.
narwe, is from S. nearu, 627, 7385, etc.
worthi, worthy (as if from weorþig) is from S. weorþe, wyrþe, 285, 461.

§ 30. The following adjectives and adjective pronouns, though ending in a consonant in Saxon, have sometimes, or always, the termination **ë** in Chaucer, resembling the nouns in § 13 (compare *Lat.* atrox, *Ital.* atroce; fallax, fallace, etc).

alle (S. eall, all, L. al, O. all, alle), 1247, 1686, 2704, 4586, 9623, 13589, 14015, 14472, etc.;
but al, 7057, 12613, 12599, 14091, 14246, 14376.
bare (S. bær, L. bare, bar), 8755, 8771 f, 11884 f, 12660 f.
blewe (S. bleoh), 566.
eche (S. ælc, L. ælc, æche, O. illc), 1184.
evene (S. efen, L. efne, O. efenn), 83, 3316.
faire (S. fæger, L. fæir, fæire, O. faȝȝerr), 2388, 2665, 12043;
but, fair, 165, 575, 3233, 7835 f, 9147 f, 9431 f, 14432 f.
fawe (S. feah = fægen, as in feahlîc), 5802 f.

foule (S. fûl, L. ful, fule, O. fule), 6645, 6664 f.
fresshe (S. færsc, L. freche, frech, O. fressh), 2388, 9656, 9733, 10698.
grete (S. greât, O. græt), 4754, 9100, 9848, 10783, 15885;
but, gret, 341, 439, 749, 1189, 1247, 1401, 2485, 4814, 5100, etc.
highe (S. heâh, L. hæh, hæhȝe, O. heh, heȝhe), 7474, 8011, 8082, 12436 f, 14055;
but, highĕ, 11047, 11085; high, 14202, 14867.
longe (S. lang, long, L. long, O. lang), 1575, 5399, 5591, 6206, 11393, 14141, etc.;
but, long, 619, 1189, 2561.
lowde (S. hlûd), 10582.
lowe (S. lah, L. loh, laih, laȝe), 3696 f, 6783 f.
merye (S. mirig, L. murie, muri), 208 f, 8491 f.
olde (S. eald, ald, L. ald, alde, olde, O. ald), 4470, 9830, 11465;
but, old, 12129, 14128, 14155, 14160.
rowe (S. hreôw, hreôh, L. ræh, ræȝe, O. ruhh), 12789 f.
shorte (S. scort, L. sceort, O. shorrt), 6206;
schortĕ, 748, 2548; schort, 93.
suche (S. swylc, L. swilc, sulche, O. swillc), 8613, 13800, 15628;
but, swich, 3, 2824.
swifte (S. swift, O. swifft), 2870.
tame (S. tam), 2188.
wete (S. wæt, L. wet), 2340.
whiche (S. hwylc, L. whilc, woche, O. whillc), 15896.
which, 4, 2677, etc.
wise (S. wîs, L. wís, wise, O. wis, wise), 11183.
wys, 67, 787, 853.
wylde, wilde (S. wild, L. O. wilde), 4170, 5858, 5955, 7742, 15166, 15402.
wild, 10126 (?).
ylle (S. yfel, L. ufele, uvel, O. ille), 4182.
y-nowe (S. ge-nôh, L. inoh, inowe, O. inoh), 12788 f.

So, as if by dropping the final consonant* (compare *Lat.* mortalis, *Ital.* mortale, etc.).

haire (S. haeren), 14151.

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forme fader (apparently from S. frumfader), ii. 335.

* ware, 16094 f, should be *war*, and chare (chariot), 16096 f, *char*, — this last not to be confounded with charë = chair, 16099.

cristne, 5630, should probably be *cristen*, but the *n* might easily be transposed.

lyte, lite (S. lytel), 2629 f, 3861 f, 7182 f.
litel occurs, 1527, 3860, 14635.
moche (S. micel, mucel), 1810, 9114, 9117, 9298, 16256.
mochil(-el) occurs, 17269, 17270.

§ 31. The following adjectives, of uncertain derivation, are found terminating in ë.

badde, 9467, 3157 f, 9482 f, 15908 f.
deynte, 15122 (deynteth, 16321); Welsh *dantaidd* = toothsome.
dronkelewe, 7625 f, 9407 f: so costlewe, iii. 115, 117.
meke, 3202, 6016 f, 14653 f; Goth. *muks*, North Friesic *meek*.
racle, 17210, 17271, 17221 = rash.
wikke, 1582 f, 5448 f: apparently allied with A. S. *wicce* = witch.

§ 32. The Definite Form of *monosyllabic* Adjectives, including Participles and Adjective Pronouns (i. e. the Adjective when preceded by the Definite Article, by any other demonstrative, or by a Possessive Pronoun), ends in Chaucer in ë.

the yonge sonne, 7.
his halfe cours, 8.
this ilke monk, 175, 723, 12008.
his owne* cost, 213, 542, 8019, 8528, 9119, 9175, 9364, 13475, 13716, 13905, etc.
the syke man, 426, 9255, 9749.
atte (at the) fulle, 653.
the seventhe yeer, 1464.
the thridde night, 1465, 14251, 14486.
thou felle Mars, 1561.
the colde deth, 2010, 2780, 7934.
his crispe her, 2167.
here hoote love, 2321, 2385, 11558.
the brighte sonne, 2439, 2291, 9622, 10099, 16252.
the derke cote, 2459, 2470, 11156.
the blake berd, 2519.
that selve moment, 2586, 2862.
the scharpe spere, 2606.
the stronge kyng, 2646, 2640, 2423 f.
the righte way, 2741, 9264.
the harde stoon, 3023.
the brode ryver, 3026.
the deepe see, 3033.
this wyde world, 3101.

* The uncontracted *owen* is often treated as a dissyllable; as, myn owen lord, 10068, 11192, 11386.

the ferre leef, 3393.
the deede sleep, 3643, 15524, 15535.
the fourthe part, 4423, 9734.
this weyke womman, 5352.
the salte see, 5459, 5529.
this glade folk, 5538, 8921.
the same wise, 8549, 10438.
thy borne man, 9664.
the slakke skin, 9723.
the smale wyket, 9919.
thy fulle frend, 9940.
this blinde knight, 10133, 13341 f.
the quyke streete, 11806.
the foule feend, 12633.
his oughne sworne brother, 14119, 14222.
this goode man, 14444.
thin false querel, 15932.

So, the foule feend, 12633.
this grete wrong, 10228, 9201.
the heighe God, 9199, 14048.
his longe tale, 9531, 13149.
his olde fader, 2840, 10133.
the whiche brook, 3921, 6537.
my whyte top, 3867, 4301, 17172.
this wise philosophre, 14035, 9477.

But these, and other similar forms, are not inserted in this list, because the indefinite forms have also, sometimes or always, a final **e**.

§ 33. So, for the most part, the Definite Form of *monosyllabic* superlatives.

{ the beste begger, 252, 9542, 11043, 13403.
{ atte (at the) beste, 29, 2209, 13403.
his moste pryde, 897, 10614 f.
{ atte leste weye, 1123, 8446 f, 11729.
{ the leste strook, 1703.
his firste purpos, 2544, 2989, 3687, 8621, 14441.
{ his laste word, 2810, 13636.
{ atte laste, 14793, 15009.
the nexte way, 1415, 2367, 2369, 10075.
the worste man, 14572, 9094.

§ 34. Among Definite Forms of the Adjective are to be reckoned adjectives occuring in forms of address (as in Anglo-Saxon, leôfa fader, etc.).

false (S. fals), "ye, false harlot," 4266, 4267, 16712. Indef. fals, 1132, 1155, 8876, 10453, 12956 f, 13610.

goode (S. gôd), "goode lemman," 4245, 8728, 13650, 16930, iii. 88, 89.—Indef. good, 514, 617, 618, 652.

But, "O good Constance," 5237.

leeve (S. leôf, L. lef, leve), "leeve brother," 1186, 7026, 14146, etc.

stronge (S. strang, L. strong, stronge), "O stronge god," 2375.— Indef. strong, 752, 1058.

yonge (S. geong, L. ȝung, ȝunge), "O yonge Hughe," 15095.— Indef. yong, 79.

It is possible, however, that some of these forms belong under § 30.

§ 35. The Definite Form of Adjectives of more than one syllable has not the final **e**.

a. Comparatives and Superlatives.

the bettir, 6133.
the ferther, 10100.
the badder, 10538.
the schortest, 838.
the oldest, 914.
the grettest, 4052, 6698, 11504, 14022.
the wisest, 4052, 15641, 12895.
the yongest, 9433, 14252, 15917.
the hihest, 11373, 11789.
the porest, 13865.
the fairest, 15637.

b. Past Participles in -ed, -t, -en.

the wenged, 1387.
the clothred, 2747.
the cursed, 4502, 4852, 4853, 5241, 5311, 5378, 7235, 12758, 13155.
his crouned, 10839.
the burned, 11559.
this sotted, 13269.
this croked, 14176.
these weddid, 14514.
the burnischt, 16350.
the broken, 1922.
this dronken, 3152, 3911, 3147, 16967.

c. Adjectives in -ed, -en, -ful, -isch, -ly, -y, etc.

thy lewed, 3147, 13807.
this naked, 10470.
the sacred, 1923.
this wicked, 4824, 5859, 8661.
this wrecched, 2997, 4694, 5338, 5378, 8726.

the golden, 2508.*
the cristen, 4800, 4806, 12463.
the blisful, 772, 5146, 7989, 9135, 11118, 12169, 12221, 13889, 14921, 14943.
this sorweful, 1072.
the woful, 1736, 4736.
thyn dredful, 5357.
this thoughtful, 8171.
my faithful, 8186, 8219.
the rightful, 12317.
here ferful, 12588.
his cherlisch, 3169.
oure elvyssh, 12679, 12770.
the Grekissch, 10523.
thy wifly, 11765.
thin homly, 9666.
the grisly, 11171.
this busy, 8010.
that holy, 9137.
this hasty, 9679.
this worthi, 10346.

So, the bitter, 5485, 11168, 11562.
hir other, 11324, 13442.
his endeles, 5371.
the litel, 4493, 5254, 5269, 8443, 8447, 14920, 14927.
the passyng, 9101.

d. Various Adjectives of Latin derivation and terminations.

this real, 8143, 10340
the vital, 2804.
th' eternal, 11962.
his cruel, 8610, 8616, 9867, 15589.
that gentil, 2799, 5048, 5611, 10580, 13719, 14606.
this subtil, 11573, 13175.
this nobil, 14473.
my soverayn, 11623, 15581.
the sodeyn, 8192.
the comyn, 4575, 8307.
thy bastard, 15864.
this present, 8346.
the parfyt, 11763.
the curious, 9451, 14635.
hir pytous, 5500, 5534, 8017, 8997, 13581, 13641.
hir vertuous, 8087, 9269.
the precious, 15629.
the glorious, 15630.

* the northen, 1989, should be the northern.

§ 36. The following exceptions to § 32, § 33, § 35, *a*, occur, but many of the readings are suspicious.

a. To § 32.

the gret, 2387, 2525, 14402.
his high, 2539 (?), 9534 (?), 14328 (?).
the dreynt, 4489 (?).
the right, 8149.
his fals, 13001.
this good, 14503 (?).
this proud, 3167 (?); (the proudë, 4311, 16245).
this fiers, 4720.

b. To § 33.

the first, 14239.
at the, atte, last, 11059, 10759, 14259.
for the best, 1849 f, 9392 f, 11198 f.
the worst, 1616.

c. To § 35, *a*.

the wofullerë cheer, 1342.
the sorwfullestë man, 9972.
the semliestë man, 17051.

§ 37. The distinction of the French masculine and feminine adjective is preserved in one case,— seint.

seint Jon, 5439, 5746, 7382, 7834, 14167.
seint Denys, 14470, 14562.
seint Jame, 5894.
seint Joce, 6065.
seynt Symoun, 7676.
seint Loy, 120, 7146.
seint Martyn, 14559.
seintë Mary, 7186, 9211, 9773, 10292, 13723, 14100.
seyntë Charité, 1723, 7701, 16806.
seintë Trinité, 7406.
seyntë Frideswyde, 3449.

But seynt Cecile, 12482, 12478.
vv. 3483 – 3486 are corrupt.

[So, apparently, in Layamon, seint Myhhel, seinte Marie, Vol. iii. p. 38.]

§ 38, *a*. The Comparative Degree of the Adjective is generally formed in Chaucer, as in modern English, in -er (S. -re).

lever, 295.
besier, 324.
slyer, 6904.
badder, 10538.

gretter, 865, 12545; grettere,* 1167.
fairer, 1037; fairere,* 756.
fresscher, 1039, 11239.
sother, 12142.
gladder, 13269.
merier, 16337.

b. A few Comparatives of "irregular" Adjectives retain the Saxon ë.

worse, werse (S. wyrse, L. wurse, wurs, O. wersse), 8551, 9667, 17252, 10914 f.
wersĕ, 1226 (?); wors, wers, 8503, 3731 f.
lasse, lesse (S. læsse, L. O. lasse), 14280, 17268, 14895 f, 15357 f.
more (S. mâre, L. O. mare), 219, 1557, 4050; mor, 16255, 7485, 10648; moo, mo (plur.), 578, 810, 9286, 9987, 10615, 12651, iii. 132.
bettre* (S. betere, O. bettre), 526, 650; bet (in Sax. adverbial form), 4534, 4731, 10914, iii. 123, 128.

c. The vowel change of the "ancient" comparison is found in the following: —

(long, 619), lenger, 332; lengere,* 823.
(old, 3865), elder, 15746; his felaw, which that *elder* was than he, 14941; eldest, 15898; (oldest, 914.)
strenger, 14240; strengere,* ii. 373; for though he werë strong, yit was sche *strenger*, 16007; strengest, 15561.

d. Some analytic forms of comparison are found.

mo slakke = slacker, 14824.
more heigh, more lowe, iii. 153.
the moste stedefast, 9425.
the moste deintevous, 9588.
the moste free, 11926.
the moste lusty, 17039.

the moste grettest occurs ii. 374.
(fer, 3395, 4013), ferrest (S. fyrrest) = furthest, 496.
next (S. nyhst, next) = modern nearest, 2367, 10075.

§ 39. The Plural of Monosyllabic Adjectives ends in ë. The same is the case with some of the Pronouns and with many of the Cardinal Numbers.†

* These forms in -re are all suspicious. Those of three syllables (if correctly spelt) are contracted in reading, so that the metre does not determine their validity, and *er* and *re* are easily interchanged. See § 84.

† Those from four to twelve, inclusive, took an -e in Saxon when used absolutely.

a. blake (S. blac, sing. blak, 913, 2132), 559, 9953 f, 11171 f, 12485 f, 16422.
blynde (S. blind, sing. blynd, 10214, 15483), 4973 f, 10244 f, 15563.
cold (S. ceald, sing. cold, 1577, 4346 f), 1304 f, 11176 f.
dede (S. dead, sing. deed, 1201, 1276), 7090, 11493.
deve (S. deaf, sing. deef, 448), 12214 f.
dulle (S. dwal, dol), 4622 f.
goode (S. gôd, sing. good, 183), 3156, 9416.
hore (S. hâr, sing. hoor, 3876, 9338), 7764 f.
hote (S. hât, sing. hoot, 7018), 9682.
reede (S. reod, sing. reed, 1912), 90 f, 12443 f, 16416, 16417.
sadde (S. sæd, sing. sad, 17207), 17190.
scharpe (S. scearp, sing. scharp, 2005), 475 f, 2028, 9033.
sclendre (sing. sclender, 16319), 9476 f.
seeke, sike (S. sŷc, sing. sik, 16323 f), 18 f, 245.
slakke (S. sleac), 14824.
smale (S. smæl, sing. smal, 158), 9, 146, 8256 f, 17005.
stronge (S. strang, sing. strong, 637, 1058), 2137 f, 14204 f.
wayke (S. wâc, sing. weyk, 14892), 889.
wrothe (S. wrâð, sing. wroth, 7743 f), 1181 f, 6821 f.
wyde (S. wîd, sing. wyd, 493), 28 f, 93 f, 559 f.
yonge (S. geong, sing. yong, 79), 213, 1013.

So, sworne brethren, 6987; gilte cheynes, 15850.

b. bothe (S. bâ-twâ), 1841, 1858, 6644, 7613.
fele (S. fela), 8793.
fewe (S. feawe, feawa), 641, 7432 f, 8099.
othere, othre (S. other), 3232, 10803, 15640;
but other (uncontracted), 7369, 7477, etc.
suche* (S. swylc), 8215, 10541, 12723, 15761.
whiche* (S. hwylc), 1015, 4500, 9170, 9319, 10295, 16156.

c. twayne, tweye (S. twegen), 8526 f, 706 f, 8947.
foure (S. feower, -e), 2141, 3883, 13388.
fyfe (S. fîf, -e), 462 f, 12483.
sixe (S. six, -e), 14585.
sevene (S. seofon, -e), 7587 f, 9514 f, 12748?
but seven, 16352, 16678.
twelve (S. twelf, -e), 4139 f, 7840, 14639;
but twelf, 7839.
threttene (S. þreottyne), 7841.

* suche, whiche, occasionally are used for the singular also.

fiftene (S. fîftyne), 61 f, 16343.
eyghteteene (S. eahtatyne),* 3223.

§ 40. The plural of adjectives and participles of more than one syllable has no -e.

a. corsed stories, 4500, 14007, 15096.
countrefeted letters, 5229.
weddid men, 8498, 9104, 9525.
cered poketts, 12736.
sleves purfiled, 193.
broken sleepes, 1922.
colours longyng, 10353.
they thankyn galpyng, 10668.

b. skalled browes, 629.
lewed wordes, 10023.
wikked werkes, 5414, 6267, 16102.
wrecched wommen, 952, 8726; wrecchede, 923?
sacred teeres, 1923.
golden clothis, 5927.
cristen men, 4800, 4960, 4967.
open werres, 2004.
thinges spedful, 5147.
woful wrecches, 1719.
synful deedes, 6740, 11965.
careful sikes, 11176.
blisful sydes, 11971.
seely clerkes, 4098, 7488.
mighty werkes, 4898.
litel children, 4493.
bitter teeres, 2227.
wiser men, 9443.
other men, 12672, 13981; 8312, absolutely.

c. certeyn yeres, 2969, 3195, 4900, etc.
mortal batailles, 61.
cruel briddes, 15586, 1305.
gentil men, 6693, 11021.
subtil clerkes, 9301.
parfyt blisses, 9512.
jelous strokes, 2636.
eldres vertuous, 6736, 10155 f.
pitous teeres, 12329.
sightes mervelous, 11518 f.

§ 41. Even monosyllabic participles *standing in the predicate* are unvaried in the plural. The same is sometimes the case with monosyllabic adjectives.

a. were hurt, 2710.
been born, 4706.
ben went, 9575.
were kept, 10003.
been maad, 2091, 5698, 5700, 10536.
ben knyt, 11542, 14451.
ben stert, 11689.
be brent, 13335 f.
sworn were, 13392.
were slayn, 15525.

b. quyk (they were), 1017.
were glad, 5804, 6930, 8251, 8880.
were fayn, 2709.
which they weren, 40.
were wroth, 8313.
(were) lik, 16354.

But, blakë were, 559.
were seekë, 18 f.
waykë ben, 889.
weren wydë, 28 f, 93 f, 559 f.
ben devë, 12214 f.
dedë were, 11493.

§ 42. Exceptions.

To § 39, *a.* brent bones, 12687.
§ 39, *c.* enleven (S. endlufon), 17300.
§ 40, *a.* lernede men, 577? lerned men, 14389; eyen fast y-schette, 4980 f? (Qu. fastë schette?)
§ 40, *c.* dyversë freres, 7537, 10516, 13026 f; dyversë folk dyversëly they seyde, 3855, 4631, 9343, 10516; dìvers freres, 7532; thay ben so dyvèrs, 7588 f.
§ 41. been mette, 1638?
weren feldë, 2926?
they be i-mette, 5535.
ben sette, 5538.
were made, 5702? been maad, 2091, 5698, etc.

§ 43. The following adjectives (of French origin) exhibit the French plural in s.*

(places) delitables, 11211 f.
(necessaries as ben) plesynges, 5131 f.
wayes espirituels, iii. 82.
goodes espiritueles, iii. 104;
but thinges espirituel, iii. 183.
travailes that ben covenables, iii. 148.

§ 44. Of the Genitive Plural of Adjectives there remains a trace in the word all; e. g.:—

here aller (S. eallra) cappe, 588.
your alther cost, 801.
oure althur cok, 825.

* I should have added to the note on p. 468, "except perhaps eahta, nigon, endlufon."

* Even Palsgrave says (1530) pronownes primytyves, verbes actyves parsonalles.

altherbest = *Germ.* allerbest, 712.
altherfirst = *Germ.* allererst, 10863, 9492, 12351, ii. 343.

So, alderlast, *Black Knight*, 503, 561.
alderlevest, *Troilus*, iii. 239.

PRONOUNS.

§ 45. (The forms and inflections of *all, each, such, which, ilk, own, same, self, both, fele, few, other,* are given with those of Adjectives, at §§ 30, 32, 35, *c*, 39, *b*, 44.)

Personal Pronouns, and their Possessives.

yk (S. ic) = I, occurs 3865; ich, 10037; also in theek (thee ik), 3862, and theech (thee ich), 12857, 14362.

my (S. mîn), sing. my lady, 1145; my counseil, 1149; my brother, 1163, etc.

myn aventure, 1162; farwel, my swetĕ, farwel, myn Emelye, 2782.

myn herte may myn harmes nat bewreye, 2231.

myn lokyng, 2471.

plur. my cheekes, 2329; my sorwes, 2421; myn heeres, 3868; myn armes, 2249.

absolute forms: myn be the travail, 2408, etc.; so, cosyn myn, 1283, etc.

mynë ben the maladies, 2469; the cokkes wordes and not mynë, 16751.

neghëbour of mynë, 15387; so, yonge children mynë, 8969 f.

thy (S. þîn), sing. thy cosyn, 1133; thy name, 1588, etc.

thyn othe, 1141, etc.; thi ayel, 2479?

thin herte, 2393, etc.

thyn werk, 5348; thyn crowdyng, 4719; thyn sikernesse, 4845; thyn gentilnesse, 5273; thyn fortune, 16147.

plur. thy craftes, 2411; thy songes, 17183.

thyn floures, 1512; thyn giftes, 9937; thyn dayes, 4846; thin synnes, iii. 179, 180.

thyn blisful eyghen, 5265; thynĕ (?) verray frendes, 9178.

absolute forms: thin be the glorie, 2408; the fruit is thin, 1284.

on of thinë, 2383 f.

hir, hirĕ (S. hire, gen. and dat.): hir, 460, 3237, 3238, 3239; 16313 – 16329, sixteen cases.
hirĕ, 123, 128, 134, 461, 472, 474, 475, etc.
} gen. dat. accus.

hir thoughte ladyes oughten hir to spare,
what from hir kynreed and hir nortelrye.
3964, 5.

absol. form, heres.

our, ourĕ (S. ûre). { our, 7411, 7553, 7681. ourĕ, 34, 921, 1110, 1284, etc., etc.

ourë, sing. 6111, 6177; plur. 14248 (?).

absol. form: this gold is nought oures, 14201.

your, yourĕ, (S eôwer). { your, 7556, 7771, 7832, 7892, etc. yourĕ, 919, 922, 929, 1106, etc., etc.

yourë, sing. 16414?

absol. form: I wil be youre, 13176; youre is the charge, 13510. [14695.

I am yourës al, 10911; my gold is yourës, an old felaw of yourës, 14087 f.

(our prayeres ben mor acceptable) than yourës, 7496.

her, hir, herĕ (S. hira) = their: — her, hir, 7509, 7510, 7514, 7523, 7580, 8256, 13510, etc., etc.

herĕ, 11, 32, 1018, 2036, 2575, 2597, etc., etc.

absol. form: heris, 7508.

hem (S. him) = them: 11, 31, 2574, 7510, etc.

The Saxon genitives mîn, þîn, ûre, eôwer, are declined (like adjectives) for possessive pronouns, but not the genitives of the third person.

Of the above forms, some of those in ë must be regarded as adjectives declined.

§ 46. In Saxon, sylf, *self, same*, was declined like an adjective both definitely and indefinitely, and agreed with the pronoun to which it was attached; as, ic sylf, or ic sylfa, *I myself;* be me sylfum, *by myself.* The forms ic me-sylf, þû þe-self, *I myself*, etc., also occur. The following are the combinations of the personal pronouns with *self* in Chaucer: —

myself, 11735.

myselve, 9334, 11674.

myselven, 805, 14590.

thyselven, 1176.

himself, 219, 15323, 15941.

himselve, 530 f, 537 f, 4464, 6737.

himselven, 1479, 9714, 11513, 12912.

hirself, 11717.
hirselve, 10698 f, 10732, 10951 f.
hirselven, 11727, 11745, 16854.
youreself, 1837, 9614, 10768, 14157.
yourselve, 8350, 10772.
yourselven, 6809, 10556.
hemself (= themselves), 1256; ii. 384; iii. 89.
hemselfen, 11690.

§ 47. Demonstratives, and others.

that (S. neut. þæt), definite article = the, as in "that oon — that other," 1351, 1353, 7603, 9350, 9351, 12151, 12152, 14222, etc., etc.
tho (S. plural þa?) = those; oon of tho that, 2353.
who ben tho that, ii. 354, 355.
and tho were bent, 3246.
tho wordes, 500, 10256.
they (S. plural þa), 16, 40, 41, etc. (their and them do not occur).
thi, 1755, should probably be thei ("gentil men thi were").
thes, plur. of this (S. þâs), 2189, 10607.
this, plur. of this, 1060, 2625, 2837, 4230, 12138, 12209, 17119, etc.
thesĕ (?) " " 9150, 11555, 11613, 14076, 14307, 14913, 15040, 16687, 16688.
thisĕ (?) " " 9110.
whos, genitive (S. hwæs), 5062, 5438, 7350; iii. 176, 178.
everich = every, each; whan tweye han everich wounded other, ii. 327.
everich wolde aske his oughne thing, iii. 370, etc.
on, oon (S. ân) = one, 3815 ("herd on crie"), 2711 f, 343, 16470.
o, oo, 343, 2735, 5985, 16470.
non, noon (S. nân): — non auditour, 596; noon harm, 5256; noon deynteth morsel, 16321.
no: — no cost, 192; no dore, 552, etc.
plur. noon holy men, 178; noon countrefeted termes, 13466; noon hasardoures, 14028.
non dremes, 16455.
noon, absolute form, 320, 344, etc., as in English.

For some peculiar uses of pronouns, see further on, §§ 102, 103, 104.

VERBS.

§ 48. Present Indicative. — The First Person Singular of the Present Indicative terminates in **ë**.

I make, 895, 1735.
recche, 1400.
drede, 1595.
have, 1607.
aske, 1741.
forgeve, 1820.
knowe, 2113.
love, 2769, 12164.
rede, 3073.
warne, 3583, 13219.
swelte, 3702.
mene, 5061.
beschrewe, 6427.
wynne, 7014.
desire, 8383.
I doute, 9315.
trowe, 10765.
thanke, 11616.
take, 12220.
pronounce, 13750.
stonde, 13806.
preche, 13808, 13839.
rekke, 13820.
telle, 13832.
knokke, 14145.
saye, 14146.
wane, 14147.
graunte, 14237.
praye, 15429.
etc., etc.

But,

I bequethĕ, 2770.
trow, 1803, 3665, 10527, 17312.
I felĕ, 9332, 9338.
hopĕ, 9548.
redĕ, 14208.
I answèr, 4892.
schrew, 7024.
I fel, 2234 f?

§ 49. The Second Person of the Present Indicative ends in **-st** as in modern English. But sometimes in **-s**.*

thou saist, 12408.
thou sest, 13047.
sclaundrest, 13623.
discoverest, 13624.
etc., etc.
So, lixt (for ligst, A. S. lygst), 7200, 7343.
goddès of maydenes that myn hert has knowe, 2302.
thou wytes, 4528.
thou ne has, 5051.
what dos thou, 10241.
says thou, 12188.
thou spekis, 12420.

§ 50. The Third Person ends generally in **-eth**, **th**, occasionally in **-es** (**is**).

priketh, 11.
seith, 743.
schyneth, 978.
laugheth, 1496.
takth, 5562, etc.
bathis, 8961.

* The second and third persons occasionally, but very rarely, end in Anglo-Saxon in *is*.

bereth, 798.
telleth, 799.
comth, 5204.
makth, 5318.
bigynnes, 16168.
writes, 5764, 17326.*

So, fares, 4021; falles, 4025; gas, 4035; bringes, 4128; says, 4178; has, 4203; all in the language of the Clerks in the Reeves Tale.

§ 51. But Saxon verbs which have t or d for the last consonant of the root, and one or two which have s, form the Third Person Singular in **t**, as in Saxon.

sitt, sit, syt, 3641, 3817, 6291, 9153, 9821, 10036, 10131, 10164, 10189, 10391, 10493, etc.
set, 7564.
writ, 6291; 16609?
let, 8465.
smyt, 7998.
light, 5526.
put, 13788, iii. 88, 128.
hight, 1974.

stant, stont, 3677, 7615, 9896, 10485, 10496, 10630, 11566, 12101, 14525, etc.
fynt, fint, 4069, 4128, 5570, 12146, 13800.
grynt, 5971.
sent, 9027.
hut, 10825.
holt, halt, 9224, 12849.
byt (bids), 187, 9251, 10605.
byt (abides), 13103.
rit, ryt, 10483, 12536, 17011.
slyt, 12610.
chyt, 12849.
blent, 13319.
schent, iii. 161, 162.

rist, ryst, arist, 3688, 4685, 5284, iii. 83.
kyst (?), 4805, 7386.

Exceptions sometimes occur, a dissyllabic form being used, as also in A.-Saxon.

sittith, 1601, 8414, 9718, 10200.
byddeth, 3641.
rideth, 14734.
stondith, 14060.
kissith, 9822.
ryseth, 1495, 13662.
bihetith, iii. 102.
heetith, iii. 111.
putteth, iii. 131.

§ 52. The Plural of the Present Indicative ends,—

a. in **eth** (**ith**, **th**) = S. -ath.

meteth, 1526.
doth, 1533.
schyneth, 2045.
goth, 2567, 2604.
clepith, 3759.
beth, 4052, 4544.
saith, 4207.
fleeth, 4541.
loveth, 5903.
maketh, 6740.
delyvereth, 7306.
sittith, 9584.
weneth, 9988.
hath, 12651.
knoweth, ii. 376.
haveth, ii. 361.
bitydeth, ii. 345.

* See note on preceding page.

b. more commonly in **-en, n** (**yn**):

maken, 9.
slepen, 10.
longen, 12.
knowen, 732.
ben, 764.
gon, 771, 1269.
comen, 803.
spenden, 808.
han, 851.
tellen, 861.
pertourben, 908.
beseken, 920.
sayn, 1200.
faren, 1267.
seeken, 1268.
seen, 2605.
loven, 6507.
arn, 8218.
thankyn, 10668.
clepen, 14090.
doon, 14912.
rennen, 16669.

c. sometimes in **e**:

wende, 16 f.
knowe, 644.
laboure we, 7064.
fynde, 9156.
lyve, 9157.
take, 11552.
wene, 9156, 13764.
come, 13892.
gete, 13956.
caste, 13957.
say, 8507 (contracted?).

§ 53. Imperfect Indicative.

Simple (or "Regular") Verbs.

a. The Imperfect of Simple Verbs is often formed by adding **-ede**, **-de**, or **-te** to the root, with occasional change of vowel,— as in Saxon.

lovede, 45, 97, 446.
semede, 387.
lakkede, 758.
weddede, 870.
lyvede, 2847.
servede, 8516.

fedde, 146 f.
hadde, 449, 619, 14605.
herde, 1125 f, 14929.
answèrde, 1126 f, 1716, 3492, 3777, 7088, 7897 f, 11889.
seide, 1601, 2670, 14130, 14136, 14166, 14385, 15077.
deyde, 2845, 2848.
sende, 4134 f.
made, 13532.
wende, 14197 f.

wente, 78, 255, 2811, 14252.
kepte, 444, 4916 f.
highte, 618, 862, 1193, 4012, 7908, 10344, 10347, 15606, etc.
hente, 959 f.
alighte, 985 f.
fette, 8550.
laste, 10887.
faste, 12067 f.
mette, 14128 f.
grette, 14129 f.
coste, 15146.
schente, 16327.
sente, 2982.
slepte, 4917 f.
broughte, 11876.
taughte, 14099.

b. The Imperfect Indicative often (perhaps more

commonly) drops the *e* of the above-mentioned terminations.

loved, 166, 1198, 1204, 3222, 4418.	prayed, 15011.
loked, 2044, 2521.	caused, 1097.
trowed, 2103.	had, 3191, 3388.
answèrd, 3136.*	seyd, 2707, 4234, 5647, 13361.
grasped, 4291.	wend, 4302.
dwelled, 1978, 4554.	nold, wold, 4378, 13312.
semed, 39, 315, 324, 2664, 13230.	schuld, 2707, 4008, 17081.
defendid, 5642.	herd, 4166.
thanked, 15665.	styked, 4929.
went, 3319.	woldĕ, 278.
clapt, 3738.	madĕ, 2990.
hight, 1015, 4011.	answerdĕ, 12261, 12359.
put, 13236.	saydĕ, 14100.
thought, 1387.	laydĕ, 15585.
brought, 11585.*	

c. The Second Person Singular of the Imperfect Indicative of simple verbs is formed in **-est**, like the Saxon, and English.

lovedest, 1164.	usedest, 2387, etc.
brendest, 2386.	haddest, 2389, etc.

But thou axid occurs, 7064.

§ 54. Imperfect of Strong, Complex, or "Irregular," Verbs.

a. A few verbs have, besides the Strong Imperfect, a later form of the other conjugations, e. g.: —

sleep (S. slêp), 98, 5165, 9731; slepte, 4192 f; slept, 11033.
weep (S. weôp), 2823, 2880, 8421; weptĕ, 148.
creep (S. creâp), 4224, 4258; crepte, 4191 f.

The following cases are suspicious, and some, if not all of them, bad readings: —

bifelle, befille, fille, 9771, 10390, 10007, 10883.
dronke, 7643.

* The rhyme in this and several other cases will show conclusively that the final e was actually dropped, and not simply left off by the copyists: —

brought (rh. nought), 11585.
went (rh. yhent, participle), 12462.
asterted (rh. converted, part.), 4857.
ameevyd (rh. agreeved, part.), 8374.
redressed (rh. oppressed, part.), 11748.
aspyed (rh. allyed, part.), 16014.
ayled (rh. i-sayled, part.), 16586.

eete, 15703. (Tyrwhitt has a good reading.)
come (to), 1729 (should be, "com unto").
badde (foure), 4911 (should be, "bad the foure").

see has various forms: saw, 11503, 11505; saugh, 193, 766; seigh, 852; seyh, 957; say, 8543, 15929, etc. (A.-S. seâh, sêh.)

sihe, 11162 f (if correct), is an instance of an ë arising from the softening away of a guttural.

ryngede (the tromp and clarioun) occurs 2602; rong, 14077. The conjugation of the A.-Saxon *hringan* is uncertain, but it would be strange if a verb weak in Saxon had become strong in English.

b. The 2d Person Singular of the Imperfect Indicative of Strong Verbs (which in A.-Saxon terminates in **e**) has commonly in Chaucer no termination, or is the same as the 1st and 3d.

thou bihight, 2474.	thou bar, 8944, 11976.
" saugh, 5268.	" spak, 12422, 14168.
" swor, 8372.	" dronk, 15712.

thou flough, 16717.

thou were, 16146 f, 16718, iii. 180, 181; werĕ, nerĕ, 4786, 13635, 15866, 15888, 15892, 17177. " gav*e*, 15937. " songĕ, 17226.	The e is doubtful in these, and especially in gav*e*, songĕ.

knewest occurs, 4787.
hightest " 8372?
bygonnest " 12370.

§ 55. The Plural of the Imperfect Indicative (both of Simple and Complex Verbs) ends, —

a. in **-en.**

wolden, 27.	dronken, 822, 2716, 15686.
weren, wern, 28, 29, 593, 630, 958.	fillen, 951.
	faughten, 1838.
prayden, 813.	ronnen, 2927.
ferden, 1649.	seeten, saten, 2895, 11520.
foyneden, 1656.	founden, 4663.
brenden, 2427.	songen, 5798.
passeden, 2576.	comen, 8353.
oughten, 3964.	gaven, 12343.
sayden, 6507, 6509.	token, ii. 382; tooken, ii. 365.
broughten, 8683.	
wenten, 11525, etc., etc.	

b. in ¨.

hadde, 375, 381, 762.	founde, 1011 f, 14184.
sayde, 1435.	blewe, 2514.

hatede, 8607.	come, 2577 (comĕ, 14184: com, *sing.* 14090).
wiste, 11801.	fille, 2668 f.
schulde, 14233.	songe, 9609 f, 11024 f.
	byhighte, 11639.

Or, *c*, has no termination.

schuld, 2543, 4898, 14233.	sawgh, saugh, seigh, 4638, 7121, 9565, 9678, 13034.
cried, 2564.	
besought (rh. nought), 4116.	bigan (rh. man), 5767; bygon, 7142.
had, 5786.	schon, 9000.
sayd, 7872.	wan, 11713.
remued, 11517.	sat, 14079.
herd, 14251.	com, 16473.
used, 14910.	fond, 16476.
	ran (rh. man), 16867.

§ 56. The Singular of the Subjunctive, both Present and Imperfect, terminates uniformly in **ë** through all the persons.

a. Present.

if gold ruste, 502.
(the martir) quyte you, 772.
(though) he have, 1323.
how sore that me smerte, 1396.
pray I that Arcita me bere, 2258.
God spede yow, 2560, 771 f.
God save yow, 2565.
but if thou madde, 3158.
(Crist) blesse this hous, 3484.
if thou wreye me, 3507.
though thou aske, 3557.
(that non) ne speke, 3586.
God forbede, 4337, 11914, 13303.
or thou come, 4539.
speke we, 5374, iii. 138.
if it like to this companye, 6860.
til it be so that thou forsake, 7104.
if eny have, 7115.
(we pray) that he the sende, 7528.
God yelde yow, 7759.
(it liketh) that I yow wedde, 8222.
God schilde that it scholde so byfalle, 9108, 3427, 14675, 14697.
though Theofrast liste lye, 9171.
schapen that he faile, 9506.
tyl myn herte breke, 10180.
and if thou drede nought, 12405.
sitte we doun, 13123.
bytyde what bytyde, 15282.
to oure hihe goddis thanke we, 15683.
as wis God helpe me, 16894.
so sore that the bihove, ii. 344.
he us bringe, iii. 187.

Several of the above forms would, by the modern definitions, be assigned to the Imperative Mood, but etymologically that view would be incorrect. The Anglo-Saxon had Imperative forms for only the second person. Thus, go we, 14634, is expressed in Saxon with the subjunctive, *gan we* (Apollonius), when the auxiliary *uton* is not used. So, *to-becume* þîn rîce, *geweorðe* þîn willa, thy kingdom come, thy will be done. (Matthew vi.)

Exceptions: no man ne draw, 2549.
havĕ thou ynough, 5911, 5918.
God help me so, 16911.
(I pray) that never dawĕ, 10069.

b. Imperfect.

and though the ones on a tyme mysfillë, 2390.
that if so were that enything him smertë, 10879.
God schildë that he deydë, 3427.
for haddë God comaundid, 5651.
for though he werë strong, 16007.

Exception: for if ther fellĕ to morwe such a caas, 2112.

c. The Plural of the Subjunctive is in **-en**, **e**.

or ye me sleen, 11634. or that ye brekĕ, 11632.
lest that thay deidin, 7483.

§ 57. Imperative.

In Anglo-Saxon the 2d person singular of the Imperative consists of the root of the verb, and terminates, therefore, in what is called the characteristic consonant; except that verbs whose infinitive is in *-ian* (1st Conj., 1st class) have the Imperative sing. in **a** (as *lufian*, *lufa*), while those which have a double characteristic drop one of the consonants and replace it with an **e** (as *sittan*, *site*). The plural of the Imperative is the same as that of the Indicative, and ends in **ath** (**iath**), when the pronoun or subject goes before or is omitted, or in **e**, when the pronoun which is the subject follows.

In Chaucer, the Imperative exhibits considerable irregularity. The **a** of the Saxon Imperative singular of the 1st Conj. becomes **e**, which **e** is sometimes shortened or suppressed. The full plural form (in **-eth**) is of very frequent occurrence; but some-

times the -th appears to be dropped, and very frequently the whole termination. In this case the plural is not to be distinguished from the singular form, and both are found together.

§ 58. 2d Person Singular.

a. Simple Conjugation.	*Exceptions.*
aske, axe (S. âsca), 3557, 14082.	
herkne, harke (S. hercna), 9186, 7133.	herk, 7500.
grope (S. grâpa), 7723, 13164.	
knokke (S. cnoca), 3432.	
thanke (S. thanca), 16172.	
have (S. hafa), 2421 ?	havĕ, 2227, 2394, 3551, 3726.
loke (S. lôca), 7169, 7838, 15109.	lokĕ, 3549, 13164, 14084, 14245.
	schewĕ (S. sceawa), 7675.
	mak (S. maca), 3720.
telle (S. tele), 7026, 15567.	tellĕ, 3433.
bygynne (S. begine ?), 13049 f.	tel, 7345, 12543, 14171, 14807, 15058.
	fettĕ (S. fece), 3492.
lef (S. laef), 1616.	levĕ,* 7671 ?
fynd thou (S. find), 2246.	
speed (S. spêd), 3562, 3726.	
stynt (S. stint), 3146.	
keep (S. cêp), 6488, 14843, 17251, 17294.	
red, reed (S. rêd), 17276, 17277.	
send (S. send), 2327, 3598.	
plight (S. pliht), 6591.	
thenk (S. thenc), 10039, 17250, 17294.	
thou bek (S. bêcn), 17278 (pronoun before).	
	recchĕ (S. rêc), 12626 ?
	yeldĕ (S. gild), 13604 ?
	wrekĕ (S. wrêc), 15391 ?

b. Complex Conjugation.	*Exceptions.*
spek, 3803, 12621, 17278.	
ber, 7569.	
brek, 15413.	
com, 6015, 7184, 16493.	
et, 15936.	
gif, 2262, 2422, 7185, 16947.	
hold, 2670, 12621, 16969.	
bihold, 16501.	
awak, 4260 f.	awakĕ, 4286? 16947?
tak, 2228, 7113, 12122, 13048, 13639, 14057, 17095.	takĕ, 9172 ? thou take, 15937 ?
far (well), 14675, 14775, 15927.	
let, lat, 923, 6015, 7184, 17107.	letĕ, 3713 ?
do, 2407, 11368, 14806.	
go, 3431, 14082.	
	wepĕ, 2480 ?
fynd, 2246.	
drynk, 7635.	
help, 2088, 2404, 3610, 3813, 14884, 16492.	
smyt, 17217.	
rys, 13133, 10012.	
wyt, 10051.	
abyd, 5751.	
ches, 1616.	chesĕ, 1597 ?
be, 6488.	rydĕ, 15413 ?

* The superfluous final ĕ in levĕ, and in all the forms which follow in the same column, is altogether suspicious, and probably should be dropped.

c. In the following cases the final *e* is difficult to be accounted for, unless an abridged plural form is confounded with the singular.

holdë thy pees, 9606. (Tyrwhitt has *hold thou.*)
werkë by counseil, and thou schalt nat rewe, 3530.
. . . . . I praye the . . . . .
as sendë love . . . . . 2319.
ne with no wood man walkë by the way, 7669.

§ 59. Plural.

a. draweth, 837, 840.	telleth, 11927, 14538, 14540.
smyteth, 784.	saith, 12103.
herkeneth, 790, 830, 7238, 14111.	kepeth, 12154.
cometh, 841, 14340.	understondith, 13093, ii. 353.
stynteth, 2676.	takith, 12987, 13104.
trusteth, 3090.	sendeth, 14029.
haveth, 1112, 11012.	levith, 14074, ii. 361.
goth, 2560, 2562.	giveth, ii. 379.
telleth ye, 3120.	studieth, 843.
doth, 8528, 11377.	saveth, 4649.
axith, 8529.	prayeth, 7236, 7245.
beoth, beth, 3578, 7883, 14098.	retourneth, 8685.
wakith, 7236.	considerith, 9705.
reweth, 11286.	examineth, ii. 348.
holdeth, 11376.	

b. Occasionally, the Plural of the Imperative, if the MS. be correct, loses its final consonant.

awake, 3700.
bithe, 7191.
trille, 10642.
youre pacience ye holde (an undoubtedly correct form), 7779 f.
loke, 11304, 13257.
make, 14837.

c. Often the termination is entirely dropped.

hold, 785.
fight, 810.
ley, 843, 2560.
forget, 2799.
tak, 13767, 13771, 13775; takĕ, 2783, 14192.
com, 10315.
byd, 10648.
lok, 6695; lokĕ, 14352.
tel, 5768, 7005, 7086, 7885.
let (which form only occurs), 833, 842, 3085.
techĕ, 7000.
kys, 6821; kissĕ, 10058.
lenĕ, 3084, 14597, 14598.
chesĕ, 6801, 6809.

d. Sometimes the abridged plural (if we should not rather say the singular) seems to be used indifferently for the full and regular plural; in other words, the singular and plural forms are entirely confounded.

tel forth youre tale, and *sparith* for no man, 5768.
telleth your tale, and *let* the sompnour be, 6871.
goth forth, and *ley* on fastë, 2560.
awakë, lemman myn, and *speketh* to me, 3700.
stoupeth adoun! by God, ye ben to blame;
helpeth me now, as I dede yow whil er;
put in your hond, and *lokë* what is ther, 13255–7.
. . . . . thurgh *youre* gentilnesse,
. . . . . *lat thou* falle, 922, 923.
rydĕ forth, myn oughne lord, brek nought ourĕ game, 15413.
now, Cristes owne knyghtes leef and deere,
cast al away the werkes of derknes,
and *armith* you in armur of brightnes, 12311–13.
voydith youre man, and *let* him be theroute;
and *sehet* the dorë whils we ben aboute, 13064–5.

§ 60. Infinitive.

The Infinitive in Chaucer ends in **-en** (A.-Sax. **-an**), often shortened to **e**. In a few cases the termination e is dropped.

seeken, 13.
given, 232.
han, 754.
doon, 770.
speken, 792.
werreyen, 1546.
ben, 2312.
worken, 3531.
saven, 3533.
hangen, 3589.
dauncen, 4368.
asken, 4521.
ryden, 6972.
sayn, 6976.
parten, 9504.
then, 13724.

roste, 385.
sethe, 385.
drawe, 521.
snybbe, 525.
schorte, 793.
telle, 794.
make, 804.
stynte, 2452.
helpe, 2651.
abyde, 2652.
stele, 4050.
sterve, 6824.
strike, 6946.
fille, 6930.
praye, 6980.
slee, 14114.

lovĕ, 1171.
demĕ, 3194.
pylĕ, 6944.
seekĕ, 14109.
wynkĕ, 16792.
bygynnĕ, 17347.
atren, 2451.
brest, 6685 f, 9970 f.
let, 6944.
answer, 14823.

A few contracted Infinitives are sometimes protracted (?).

to seene (S. seôn), 1037 f, 9340 f, 11423 f.
to sayne (S. secgan), 10628 f, 12286 f.
to doone (S. dôn), 10648 f, 12860 f, ii. 357.

The prefix y- (S. ge-) is found in at least one case before the Infinitive.

y-knowe, 11199.

§ 61. Participles.

Complex Perfect.—The Perfect Participle of Complex ("Irregular") Verbs terminates in **en**. The **n** is often dropped.

holpen, 18.
foughten, 62.
comen, 77, 2703.
dronken, 135, 13983.
wonnen, 879.
stongen, 1081.
bounden, 13118.
seten, 1454.
songen, 1531.
unyolden, 2644.
lorn, 5194, 8947, 15526.
layn, 5307.
founden, 8396.
standen, 9368.
holde, 6526, 14017.
unknowe, 1408 f.
come, 1357.
geve, 14337.
wonne, 1004.
bygonne, 52 f.
undurgrowe, 156 f.
woxe, 9636.
songe, 1542, 15072.
clombe, 15888.
founde, 10154.
understonde, 10751.

gliden, 9761 f. withstonde, iii. 173.
abiden, 9762 f.
clomben, 16684.

The contracted participle is in a few cases protracted (?).

sene, seene (S. segen), 134 f, 594 f, 926 f, 1967 f, 2300 f, 10959 f. say occurs, iii. 101 (?)
slayne (S. slegen), 14115.

§ 62. Simple Perfect.

The Perfect Participle of the Simple Conjugation requires no notice. *Send*, which has Imperfect *sende*, 4134 f, has Participle *send*, 10458. Some Verbs which are of the Complex Conjugation in Saxon have become simple in Chaucer, according to the well-known law. Hence we have the form *wist* for *witen*, 10574 f, 12210.

dawet, 5935,	assemblit, ii. 328,	are trivial dialectic varieties.
amendit, 7757,	troublit, ii. 376,	
constreynit, 8403,	descendit, iii. 106,	
i-feynit, 8405,	engendrit, iii. 106,	
biwaylit, 8406,	defendit, 13925,	
compleynit, 8406,		

The abbreviated forms annonciate, consecrate (like the above, common in Scotch), occur 15501, 3.

kidde, 9817 f, should probably be kid.

§ 63. The prefix y-, i-, (S. ge-) frequently occurs in Chaucer before the past participle.

i-ronne, 8 f.	y-sene, 594 f.	i-be, 10275.
i-falle, 25 f.	i-taught, 757.	y-hent, 12464 f.
i-schreve, 226 f.	y-buried, 948.	i-sayled, 16585.
i-chapud, 368.	i-brent, 948 f.	y-covered, iii. 94.
i-bore, 380 f.	y-corve, 2015 f.	i-born, iii. 106.
y-clepud, 412.	y-storve, 2016 f.	

The i- in rounde i-schorn, 591, place i-sette, 1637, etc., } is suspicious, as the final e of the first word might very easily have been carried over to the Participle.

§ 64. Present Participle.

The Present Participle terminates, for the most part, in **-yng** (Ang.-Sax. **-ende**). In some cases, however, it is rhymed with the Infinitive Mood, and we must either suppose the participle to end in yngë, or else the Infinitive to have lost its termination.

wonyng, 390.	fastŷnge, 13778.
lyggyng, 1013.	sittyngĕ, 802 (?).
romyng, 1073.	lyvŷnge, 903 f (?).
dwellyng, 1421.	lotŷnge, 12114 f (?).
rayhyng, 2505.	thunderynge (rh. sprynge), 2176.
wynsyng, 3263.	gliteryng [e ?] (rh. bryng [e ?]), 2892.
sensing, 3341.	
abydyng, 3595.	styryng [e ?] (rh. spryng [e ?]), 3673.
walkyng, 3955.	
knowyng, 4223.	wepynge (rh. brynge), 8790.
ymaginyng (rh. thing), 8474.	smellynge (rh. brynge), 12207.
	lernynge (rh. synge), 14927.
romŷnge, 10092.	

The older forms awaytand, 7634, lepand, 7739, touchand, 7872, } occur, — all in the Sompnoures Tale.

§ 65. Anomalous Verbs.

can = know, be able.

Pres. Indic.	Sing. 1, 3.	can, 373, 734, 743, 3128, ii. 333.	Sax. can.
	2.	can, 11895; canst, 17032, 17098.	cunne, canst.
	Plur.	connen, 10312, 10317.	cunnon.
		conne, konne, 3120, 4121, 7696.	
		connĕ, 13495.	
		can, 1256, 3873, 6019, 10499.	
Imperf. Indic.	Sing. 1, 3.	couthe, cowthe, 328, 2089, 10442.	cûðe.
		cowde, 567, 4368, etc.	
		couthĕ, 604.	
	Infin.	conne, 7100, ii. 376.	cunnan.
	Past. Part.	couth, 8818; coud, iii. 183.	cuð.

dar = dare.

Pres. Sing. 1, 3.	dar, 11561, 13712, 13795.	Sax. dear.
2.	darst, 1142.	dearst.
Plur.	dar, iii. 124; dor, 12589.	durron.
Imperf.	dorste, durste, etc., 227, 6975.	dorste.

may = may.

Indic. Pres. Sing. 1, 3.	may, 14571, 230.	mæg.
2.	might, 5758; may, 1920, iii. 133; mow, 12388. mayst, maist, 1245, 3151.	miht.
Pl.	mowen, 3884, 12609; mowe, 3001, 11142. mow, 6564, 7304; may, 3000, 6561.	magon.
Pres. Subj. (?)	mowe, 12228; mow, 12388.	mæge.
Imperf. Sing. 1, 3.	mighte, mihte, 586, 1272, 1370, 1407, 1476, 4142, 6505, 9640, 11415, 13547 f, 14261, 16140, 16152, 16399, 16797. might, 322, 6560, 7750, 14199, 14207 f, 14272 f, 14680, 15794, 16405, 16632.	mihte.
Plur.	mighten, 570. might, 1991, 4115, 6720, 14904, 16477.	

mot = must (*debeo*), may.

Indic. Pres. Sing. 1, 3.	mot, moot (debeo), 1171, 1297, 1647, 1648, 13641, 14164, 14421, 14429, 14571, 14597, 14773.	mot.
2.	most, must, 5922, 13640.	most.
Plur.	mooten, 232; moote, 7690, 10630; mot, 744.	moton.
Ind. Imperf.	moste, 3090, 5306, 10352, 10908, 13620, 15996.	moste.
Subj.	moste, 10890.	"
Imperf. = *debeo*: Sing. 1, 3.	moste, most (as a present = English must), 887, 1292, 4702, 11629, 14206, 14422, 14423, 14683.	
Plur.	mosten, moste, 3297, 5130.	
In the sense of *may*.	Pres. Subj. mot = may: I pray to God his nekke mot to breke, 3916; so mot I the, 6853, 9102; blessed mot thou be, 8433, 14847. Imp. Subj. most = might: (preyde) that she most kisse, 8426; so, 4800.	

(See further on, Impersonal Verbs.)

owe = *debeo*.

Pres.	oweth = *debet*, 662, ii. 334.	Sax. âh.
Imperf. Sing.	oughte, ought, aughte, aught = *debet*, 3053, 3091, 4331, ii. 364.	âhte.
Plur.	oughten, oughte: ii. 363, 365; 15863; (monkes) oughte be, 15054.	

(See further on, Impersonal Verbs.)

schal = Eng. shall.

Present, Sing. 1, 3.	schal, 1140, 1166.	sceal.
2.	schalt, 1155, 7099; schal? 1147.	scealt.
Plur.	schullen, 1823, 1824, 12169. schuln, 6526, 7932, 14639. schul, 1867, 11648, 12156; schol, 16433. schal, 4553, 4658. sul (dialectic), 4172.	sculon.
Imperf.	scholde, schulde, etc., 13566, 13667, 14859.	sceolde.

thar = need.

Pres. Indic. Sing. 3.	(he) thar.	Sax. þearf.
Plur. 2.	thar (ye), ii. 332.	þurfon.

(See further on, Impersonal Verbs.)

wot = wot, *scio*.

Ind. Pres. Sing. 1, 3.	wot, woot, 1142, 8031, 8690.	wât.
2.	wost, 1165, 1176, 2309.	wâst.
Plur.	witen, 1796, 2816, 7472, iii. 92.	witon.
	witĕ, 10305, 14796; wit, 7840.	
	wote, 1262.	
	wot, woot, 742, 831, 1837, 5782, 14584.	
Imperf.	wiste, etc., 228, 282, 8690.	wiste.
Subj. Pres. Sing.	(er thou) wite, 17217.	wîte.
Infin.	wite, 3555, 9614 f, ii. 352, 382, iii. 82.	wîtan.
Past Part.	wist, 10574 f, 12210; un-wist, 2979.	witen.
Pres. Part.	witynge, iii. 114.	wîtende.

§ 66. The verbs *wil*, *stert*.

Pres. Indic. Sing. 1.	wil, 1747, 5730.	wille.
	wol, 805, 3493, 3495; wol*e*? 811.	
2.	wilt, 12186, 12226, 17264; wolt, 3531, 3511.	wilt.
	wol, 2324.	
	wil, 12773, 13396.	
3.	wolĕ? 807; wol, 1628, 7244, 13585.	wile.
Plur.	woln, 4109, 5874, 8457, 14329.	willað.
	wol, 4131, 14215.	
	wil, 3370, 8237, 14114, 14196.	
Imperf.	wolde, etc., 144, 538, 25; woldĕ, 278.	wolde.
Subj. Pres. Sing. 3.	wile, 13583.	wille.
Past Part.	(hath) wolde! ii. 358.	

wilneth, 2566, etc., is from S. wilnian = *desiderare, cupere*.

Pres. Indic. Sing. 3.	stert, start (*springs, leaps, starts*), 5745, 6628, 7734, 10027, 11480. (All these *might* be Imperfect Tense, but less probably.)
Imperf. Sing.	sterte, 954 f, 1082 f, 1301 f, 1395 f, 1516 f, 1575 f, 1764 f.
Plur.	starte, 16863.
Past. Part.	(ben) stert (into) = jumped, 11689.
	(had) stert (out of) = started, 8936.
Pres. Part.	stertyng (as the fire) = leaping, 1504.
Infin.	asterte (escape), 1597 f, 6896, 11334 f.
Part.	ystert (*a*stert?), 1594.
Imperf.	asterte, 4895 f; but aster*ted*, 4857 (rh. converted).

§ 67. Some Impersonal Verbs.

(him) deyend, 15620, 16667; deyned hire, 15756.
(him) falles (= *opus est*), 4025.
him gained, 536.
him lakked, 10330.

(yow, hem) liketh (S. lîcað = *placet*), 779, 5679, 8187, 8188, 13397, 13399.
liken (= *placere*), 8382; that oughte like yow, 15346.

Pres. Ind., lyst, list, lest, lust (S. lyst, Imp. lyste, impersonal), 1129, 1185, 1203, 1209, 1329, 1353, 2076, 2379, 2815, 3004, 5900 f, 6819 f, 6830 f, 7067, 7330, 8069, 8366, 8809, 9192, 10432, 10436, 10437, 10634, 10641, 10645, 11406, 12098, 12162, 14973 f.

Imperf. Ind., liste, leste, luste, 752 f, 789 f, 1006, 1054(?), 8618, 10679, 10689, 10919, 11547 f.

Imperf. Subj. 9878 f.

But, yow leste, 2d pers. plur. Pres. Indic. &c. 830 f, 1355, 2210 f, 9428, 10047 f, 10439: — 8723 f is doubtful.

if thou list occurs 7567 f (Tyrwhitt, *thee*).

who so list it not to heere, 3176.

[apparently, *lest* (*list*) should be leste (liste), 7317 f, 8059 f.

apparently, *lust to* should be luste, 4897.

apparently, *leste* should be lest, 10694 f.

lest, list, 7981 f, 7987 f, 8592 f, 8862 f, 9921, are doubtful.]

me mette (S. mætan, impers., *somniare*), 16380, 16384, 16564.

But *he* mette, 16569, 16488.

us moste (*nobis opus est*), 12874.

us needeth, 6857.

the oughte, him oughte (*oportet*), ii. 357, iii. 109.

us oughte, 9026 f, 13927, ii. 325.

hem ought, ii. 348.

hir ought[e] (*oportuit*), 8996 f.

me rewith (*poenitet*), 10306.

him semeth, iii. 86, 186, etc; semeth me, iii. 89.

hem semed, 10370.

him smerte, 230, 536; me smerte, 1396.

the thar (*opus est tibi*), 5911, 5918, 6947, 17284, ii. 326.

it thinkith me (S. þincð = *videtur*), 16264, 16963;

him thenketh,* 3615.

(him, hir, me, us) thoughte, 787, 956, 3344, 3964, 10840, 16497.

me athinketh (S. ofþincð = *poenitet*), 3170.

thursted him, 15525.

§ 68. Negative Verbs.

am. Indic. Pres. Sing. 1, nam, 1276.
3, nys, 1276, 12213.
Subj. Imperf. Sing. nerĕ, ner, 1602, 7526, 13290, 17205, iii. 106.
Imperf. Sing. nas, 323, 2592, 8592, 14721, 14722.
Plur. nerĕ, 2591; nerĕ, 4967, 4968.

have. Indic. Pres. Sing. 3, nath, 925, 5682.
Imperf. Sing. 1, 3. nadde, 3751.
nad, 10212, 16983.

will. Indic. Pres. Sing. 1, nylle, nyl, 13391 f, 5628, 8239.
3, nyl, 5762.
Plur. 1, nyl, 6523.
Imperfect Sing. 1, 3, nolde, 3159, 3168.

wot. Indic. Pres. Sing. 1, 3, nat, not, noot, 1265, 7634, 13076, 16955.
Imperf. Sing. 1, 3, nyste, nyst, 4804, 6578, 12144.
Plur. nysten, 10948.

ADVERBS.

§ 69. Anglo-Saxon Adverbs have commonly, in the positive degree, the termination **e**, and this termination is preserved in Chaucer.

brightë (S. beorhte), 3352.

clenë (S. clæne, clænlîce), 12553.

deepe (S. deôpe), 129 f.

evele (S. yfele), 1129; yllĕ, 3715.

evene (S. efne), 1062.

faire (S. fægere), 94, 12060 f.

faste (S. fæste), 4192, 6552, 11159, 13033, 13351.

foule (S. fûle? fûllîce), 16964.

harde (S. hearde), 3729.

hye (S. heâhe), 2077, 3243 f.

inne (S. inne), 41 f, 10891 f, 12809.

late (S. late), 77.

lighte (S. lîhte), 6724.

longe (S. lange), 1545, 14847, 15596 f.

loude (S. hlûde), 716 f; louthe, from another S. form, hleôð, 17026 f.

nede (S. nêde), 9208, 9825 f, 13208; nedĕ (?), 14520.

* Sax. þencan = think. } Thenken = to think, occurs 9377, 1608: thynketh, 14428.
þincan = seem. }

oute (S. ûte, ût), 11407 f.
rathe (S. hraþe), 3766, 14510.
softe (S. sôfte), 2783.
sore (S. sâre), 230, 1396, 6810, 12657, 12799.
stille (S. stille), 7782.
swithe (S. swîþe), 13222.
unn-ethe (S. un-eâþe), 11659, 13318, 15037.
uppe (S. uppe, up), 10929 f.
wide (S. wîde), 4556, 8598.
yerne (S. georne), 13813 f.
ylike, yliche (S. gelîce), 7797, 7812, 8630.
yoore (S. geâre, geâra), 3895 f, 13484 f.

So, blyve (L. bilife, blive, O. bilife), 2699 f, 5973 f, 7102 f.
lowe (S. lage? adj. lah, L. loh., pl. lowe), 1407 f, 17297.
pore, 8919.

So in Layamon, clæne, ufele, efne, feire, faste, fule, harde, hehȝe (hæh), inne (in), late, longe, lude, nede, raþe, softe, sare, stille, swiþe, uneþe, uppe (up), wide, ȝeorne, iliche, ȝeare.

And in the Ormulum, æþe, depe, fasste, faȝȝre, fule, harrde, heȝhe, ille, inne, lannge, late, nede, raþe, sare, swiþe, uppe (upp), ȝeorne.

§ 70. Comparatives and Superlatives of the Ancient ("Irregular") Form.

compar. bet (S. bet. O. bett, bettre), 242, 3604; super. best (S. betst), 535.
the bet (S. þŷ bet), 5986, 7533.
But bettre, 344, 610; super. beste, 6095.
fer (S. fyr), 1852.
ferre, 48 f, 2062 f.
lenger (S. leng), 2356, 2559, 3409, 4235, 13615, 16005.
the lenger, 8563.
more (S. mâ, mâre, O. mare, mar), 7551, 8867.
ner, neer (S. near, nyr), 970, 1852 f, 12649 f, 14931 f.
neere, 14931 f (?), ("ner and neere").

Note.—bettre, ferre, lenger, more, neere, were originally adjective forms (S. betere, fyrre, lengre, mâre, nearre).

The following superlative forms are also noticeable on account of the ë in moste, &c.

O firste mevying cruel firmament, 4715.
the moste stedefast, 9425.
the moste deintevous, 9588.
the moste free, 11926.
the moste grettest, ii. 374.
the moste lusty, 17039.
the gentileste born, 7948.
But, the fairest hiewed, 16355.

§ 71. The following Adverbs have an internal e (i) which is not found in Anglo-Saxon.

boldëly (S. bealdlîce, L. baldeliche, O. baldeliȝ), 6885, 14956.
forthëweard (S. forðweard, L. forðward, O. forrþwarrd), 4683.
needëly (S. nŷdlîce), 16730.
oonëly (S. ânlîce), 2346; oonly, 8195.
softëly (S. sôftlîce), 8199, 15083.
trewëly (S. treôwlîce, L. treoliche), 775, 7929, 11222.
worthily (S. weorðlîce, L. wurðliche, wurðeliche, O. wurrþlihe), 2739.
So, semëly, 151; rudëly, 736; quytëly, 1794.

§ 72. The following Particles, of various terminations in Saxon, have -ĕ more or less frequently in Chaucer. Those marked * have also a form in -s: see § 73.

a. { aboven (S. on-, â-, bufan), 53, 2771, 7297.
above, 1802 f, 1905 f, 5789 f; abovĕ, 2029, 3213. }

{ abowten (S. âbûtan), 3645.
aboute, 892 f, 2191, 3554, 4146; aboutĕ, 2187. }

asondre (S. on-, â-, sundran), 5577; asonder, 7256 f; asondur, 493 f.
atwynne (S. on-tweônan?), 3589 f, 13098 f.
beside * (S. be sîdan), 10688 f.

{ biforn (S. be-foran), 1108, 1150 f, 1164 f, 1388.
byfore, 379 f, 3238 f; beforne, 14405. }

behynde (S. be-hindan), 3239, 7723 f; byhyndĕ, 1052.
bynethe (S. be-niþan), 4039.
bytwene (S. be-twynan), 2861 f, 3107 f.
by weste (S. be westan), 390 f.
henne * (S. heonan), 3887 f.

{ siththen * (S. siðþan, siðþa), 6826, 15597.
siththe, 4478; sith, 8225, 8721; seth, 5234. }

{ withouten (S. wiðûtan), 463, 540, 810, 823, 1851, 1856.
withoute, 785, 788, 950, 8208 f. }

by-yondĕ (?) (S. geondan, geonda, geond), 15130.

Layamon, abuten, abute, biforen, bifore, bihinden, bihinde; and so of all similar particles.
Ormulum, abutenn, biforenn, bihinndenn, etc.

b. betwix (S. betweox), 1707, 3096.
betwixe, 1212, 2172, 9348, 14247.
bothe (S. bâtwâ, L. baðe, boðe, O. baþe), 5895, 6823.
eek, ek (S. eâc, L. ec, eke), 5031, 5612, 5688, 8818.
eeke, eke, 4480, 5136, 6231, 7075, 7765, 11692, 15786 (all rh. with seeke): 6373, 7445, 15522, (all rh. with cheeke) : 16873 (rh. with breke).
evere, nevere, (S. L. æfre, æfer, O. æfre), 50, 676, 1231, 1347, 1408.
ever, never, 70, 1135, 1354, 2397, 2414; generally contracted to a monosyllable.
her, heer (S. her, L. O. her, here), 6583, 6591, 6595, 6624, 14346 f, etc.
heere, 1821 f, 3774 f, 7730 f.
ther (S. þær, þere, þara, L. O. þær, þære), 313, 323, 328, 4215, 9863, 9872, 10341.
there, 4956 f, 5222 f, 7650 f, 15037 f (less common).
wher (S. hwar, hwær, L. whær, whære), 323, 344, 9873, 10341, etc.
where, 4556, 7634 f, 9462 (less common).
nouthe (S. nu þâ, L. nuþe), 464 f.
ofte (S. oft; but Gothic ufta, Dan. ofte, L. ofte, O. offte), 1269, 9541.
ofte-tyme, 52, 358; ofte-tymes, 1314.
oft-sithe, 1879; ofte sithes, 487 (S. oft-sið? O. offte siþe).
selde (S. seld, L. selde), 10125, 8303 f.
soone (S. sona, O. sone), 15769.
eft-soone, 16082 f; eft-sones, 6390.
thanne = tunc (S. þonne, þenne, þanne, þon, þan, L. O. þanne, þan(n)), 1655, 13987, 15404, 16762, 16988; thenne, 13121 f.
than, 640, 3052; thannĕ, 12, 638, 2936, 2937, 2938, 7722.
whanne (S. hwonne, hwenne, hwanne, L. whannen, whone, etc., O. whanne, whann), 11718, 14695.
whan, 1, 5, 762, 782, 803, 824, 915, 3054, 3055.
thenne* = inde (S. thanan, thanone), 6723 f.
therefòre (S.? L. þerforen, þerfore, O. þærfore), 3506 f, 8035 f, 8188 f, 9023; therfor, 7374, 10571, 10647.
wherfòre, 13631 f.
tille (S. tille, til, O. till), 10811 f; til, 10838.
ynowe (S. genoh, L. inoh, inowe, O. inoh), 12788 f.

welle (S. wela, wel), 1663 f, should probably be dwelle, as in Tyrwhitt; but welle, wele, occur in Layamon, and wel is rh. with I fel (which possibly should be I fele), 2233.

§ 73. The following Particles, of various terminations in Anglo-Saxon, have in Chaucer the termination **-es, -s.**

ageyn (S. ongean, âgean, togeanes, L. aȝæin, aȝeines, aȝenest, O. onnȝæn, onnȝæness), 66, 4812.
agens, ageins, 1511, 8046, 8787, 10371; agaynes, 10199.
agenst, ageinst, 8196, 13597.
algates, 7096, 7393, 13024; algat*e*, algatĕ, 573, 7619; àlgat (?), 14422.
amonges (S. gemang, L. imong, amang, O. amang), 9902, 14639; among, 6534.
amyddes (S. -middan, -middes, L. amidde, amidden), 2011, 10723, 16215; in the middes (of), 16534.
bysides (S. be sîdan), 13344.
elles (S. elles, L. ælles, O. elles), 1230, 9410, 11209.
hennes, hens (S. heonan, heonane, L. heonene, henne, hinnes), 10972, 14102.
thennes (S. þanon, þanone, L. þonnen, þanene), 4930, 5463, 10640, 10641.
whennes (S. hwanan, hwana, L. whannen, whone), 12175, 13750; whens, 8464.
needes (S. neâde, neâdes, L. neode, O. nede), 1171, 7887, 10179, 13127, 16720.
ones (S. âne, L. ene, ænes, O. æness), 7259, 15767.
synnes, syns, sins (S. siðþan, siðþa), 6551, 8047, 9341, 9396, 14284, 14822.
syn, sin, 10181, 12226.
thries (S. þriga, þriwa, L. þrie, þrien, þries, O. þriȝȝess), 63, 564, 14953.
togideres (S. tô-gædere), L. togadere, togaderes, O. togeddre), 14117.
towardes (S. tô-weardes, L. towardes, toward, O. towarrd), 11883, 14121; toward, 13534, 14220.
twyes (S. twiwa, twigges, L. twie, twien, twi, O. twiȝȝes), 4346, 5478, 14958.
unnethes (S. un-eâþe, L. unæðe, O. unnæþe, see § 69), 5976, 11048.
whiles (S. þâ hwile, O. whil), 6352, 13067, 13854, 15047; whils, 13065.
whil, 1362, 6350.

now-on-dayes occurs, 13324. Other genitives used as adverbs are, his thonkes, here thonkes (S. his þances, hira þances), 1628, 2109, 2116, iii. 186; his willes, 5854.

ELISION OF FINAL VOWELS.

§ 74. Even if Chaucer followed invariable rules with regard to the pronouncing or suppressing of the final e, it cannot be expected that they should be entirely made out by examining one single text of the Canterbury Tales, which, though relatively a good one, is manifestly full of errors. A comparison of several of the better manuscripts would enable us to speak with much more accuracy and confidence. Tyrwhitt's arbitrary text may very frequently be used to clear up, both in this and in other particulars, the much superior manuscript published by Wright. Still the question whether an e was pronounced would often be one of much delicacy (as the previous question whether it actually existed is sometimes one of great difficulty), and not to be determined by counting syllables on the fingers. No supposition is indeed more absurd than that Chaucer, a master poet for any time, could write awkward, halting, or even unharmonious verses. It is to be held, therefore, that when a verse is bad, and cannot be made good any way as it stands, then we have not the verse that Chaucer wrote. But with regard to the particular point upon which we are now engaged, it would often be indifferent, or nearly so, whether a final e is absolutely dropped, or lightly glided over. Then again, as not a few grammatical forms were most certainly written both with and without this termination, the fuller form would often slip in where the other would be preferable or necessary, much depending on the care, the intelligence, or the good ear of the scribe. Very often the concurrence of an initial vowel, justifying elision, with a doubtful final e, renders it possible to read a verse in two ways or more; and lastly, hundreds of verses are so mutilated or corrupted that no safe opinion can be based upon them. Such verses as these ought plainly not to be used either to support or to impugn a conclusion; neither ought the general rules which seem to be authorized by the majority of instances to be too rigorously applied to the emendation of verses that cannot be made, as they stand, to come under these rules.

§ 75. Unaccented **e** final is commonly elided before a vowel: —

and of his post as mek*e* as is a mayde, 69.
with lokkes crull*e* as they werĕ layd*e* in presse, 81.
he knew the caus*e* of every maladye, 421.
this nobl*e* ensampl*e* unto his scheep he gaf, 498.
a company*e* of ladies, twey*e* and tweye, 900.
to prech*e*, and eek to begg*e*, it is no doute, 7294.
and beggyd mel*e*, or chees*e*, or ellis corn, 7321.
wel may his hert*e* in joy*e* and bliss*e* abounde, 9162.
for he was schave al new*e* in his manere, 9700.
the sonn*e*, and moon*e*, and sterres every way, 12036.
other to grav*e*, or paynt*e*, or forg*e*, or bete, 13432.
forsakith synn*e* er synnë yow forsake, 13701.
o moodir mayd*e*, o maydë mooder fre, 14875.
with facë pal*e*, in dred*e* and busy thought, 15000.

§ 76. Unaccented **e** final is elided before a few words beginning with **h**: —

a. Before the pronoun **he** (**his**, **him**, **hire** (**hir**), **hem**).

wel cowd*e* he dress*e* his takel yomanly, 106.
what schuld*e* he studie, and mak*e* himselven wood, 184.
for in his mal*e* he hadd*e* a pilwebeer, 696.
but maketh houndes et*e* hem in despit(e), 949.
that len*e* he wex, and dry*e* as eny schaft, 1364.
then wold*e* he wep*e*, he mightë nought be stent, 1370.
that in that grov*e* he wold*e* him hyd*e* al day, 1483.
ther durstë no wight clep*e* hir but madamë, 3954.
and fatte his soul*e*, and mak*e* his body lenë, 7462.
as techeth art of spech*e* hem that it leerë, 10418.

b. Before **hath** (**has**), and sometimes apparently before **have**, **hadde**, (**had**), though with regard to these last two words the number of cases is not enough for certainty.

1. *fortune* hath geven us this adversite, 1088, 1492, 15833.
that he ful *sone* hath plesyd every part, 2448.
as soth is sayd *eelde*, hath gret avantage, 2449.
by God, quod Johan, Symònd, *neede* has na peere, 4024.
nature hath now no dominacioun, 2760, 3009, 13424.
humblesse hath slayne in hir tyrrannye, 4585.
that hem to seen the *peple* hath caught plesaunce, 8869.
whan tendre *youthe* hath weddid stoupyng age, 9612.
so *sore* hath Venus hurt him with hir brond, 9651.
out of the *chambre* hath every wight him dressed, 9696.
and whan sche of this *bille* hath taken heede, 9826.
the *mayde* hath brought this men to blisse above, 12209.
that slydyngĕ *science* ha[th] me madĕ so bare, 12660.

this juge unto the clerk his *tale* hath told, 13557, 16604.
her may men se how *synne* hath his merite, 13692.
til he so *longe* hath ryden and goon, 15211.

But, and now so *longë* hath the tappe i-ronne, 3891 (?)

2. so *longe* havĕ thei comforted hire that sche, 11144.
upon my dedly *herte* havĕ som(e) pité, 11352.
er that he deyë, *sorwe* havĕ he and schame, 12637.
by this *gaude* have I wonne[n] every yeer, 13804.
that God wolde of his *peyne* havĕ som pité, 15527.
9308, 10005, indecisive.

But, no berd ne hadde he, ne never *scholdë* have, 691.
though that *Arcitë* have hir to his wyf, 2260.
wher might this woman mete and *drinkë* have, 4918.
that every *frerë* have as moche as other, 7716.
for though the *poeplë* havĕ no gret insight, 8118.
but sche noon answer of him *mightë* have, 8560.
I *schuldë* han ben deed long tyme agoon, 15062.
then had your *talë* havĕ be told in vayn, 16285.
8254, doubtful.

3. for though the *pope* had seten hem bisyde, 6002.
whan folk in *chirch*[*e*] had give him what hem lest, 7318.
til that the brightë *sonne* had lost his hewe, 11328.
this subtil clerk such *routhe* had of this man, 11573.
or for sche *w*[*h*]*itnesse* hadde of honesté, 12017.
1361, 7315, 11819, are doubtful; 12660, 16151, bad readings.

But, at many a noble *arivë* hadde he be, 60.*
to have as great a grace as *Noë* hadde, 3560.
namly on *beddë* hadden they meschaunce, 5989.
though he no *morë* hadde than his scherte, 9859.
54, 56, doubtful.

c. Before **how** and **her** (**heer**).

by his *clennesse* how that his scheep schuldĕ lyve, 508.
than wol I *clepe*, how Alisoun, how Jon, 3577.
but of my *tale* how schal I do this day, 4510.
seth thou art rightful *jugge*, how may this be, 5234.
thou wilt algates *wite* how we ben schape, 7096.
nought wold I *telle* how me is wo bygoon, 11628.
unto this *philosophre* how schal I doo, 11865.
me *mette* how that I romed up and doun, 16384.
of Mercenrike, how Kenilm mette a thing, 16598.
1491, indecisive.

morĕ than is myn that *sterve* here in a kage, 1296.
plight me thy *trouth*[*e*] her in myn hond, quod she, 6591.
in word and werk, *bothe* heer and everywhere, 8043.
anoon for myn *allye* heer take I the, 12225.

Exceptions (?).

I spak to him and *saydë* how that he, 6149. Tyrwhitt, said him how.
in myn *officë* how that I may wynne, 7003. T. how I may moste winne.
[In 2823, 14531, 15760, the infinitive should doubtless have an n.]
that I schal havĕ myn heven in *erthë* heere, 9521.
lordings, ensamplë herby may ye take, 15725. Here ensample may be pronounced ensampul, as in 5594.

§ 77. Except in the cases mentioned above, there appears to be no rule that final **e** should be elided before **h**.

to *fernë* halwes couthe in sondry londes, 14.
of *smalë* houndes haddĕ sche that sche fedde, 146, 2078.
and all was conscience and *tendrë* herte, 150.
God loved he best with al his *trewë* herte, 535, 8062, 8825, 10854, 12325.
the *fairë* hardy quyen of Cithea, 884.
of whichë two *Arcitë* hight that oon, 1015.
hirĕ *yolwë* heer was browdid in a tresse, 1051, 2136, 2145, 2167, 2291, 6535.
and namëly the *gretë* hert in May, 1677, 15743.
I you *forgevë* holly this trespace, 1820.
and *seydë*, help, for thou mayst best of alle, 2088.
myn is the ruen of the *hihë* halles, 2465.
al werĕ they *sorë* hurt, and namely oon, 2711.
and Symkyn *haddë* hosen of the same, 3953.
ye, *falsë* harlot, quod this mellere, hast, 4266.
it is ful *lassë* harm to late him pace, 4407.

* hadde he is sometimes contracted, and spelled as pronounced, had he, haddë, as:—

a garland had he set upon his heed, 668, 319, 351.
in termes haddë caas and domes alle, 325, 54, 578.

he hadde is generally pronounced he haddĕ (=he had?), as:—

ful oftë tyme he haddĕ the bord bygonne, 52.
for he haddĕ power of confessioun, 218, 85, 642.

sche wol not duelle in *housë* half a day, 5934.
my *fourthë* housbond was a revelour, 6035, 6085, 6169, 6669.
that sche so long a counseil scholdë hyde, 6548.
and therefor, *lievë* housbond, I conclude, 6753.
and be to yow a trewë humble wyf, 6803.
so long he *wentë* hous by hous til he, 7347, 17161.
to Crist that he the *sendë* hele and might, 7528.
his *sykë* heed is ful of vanyté, 7790.
womman of many a *scolë* half a clerk is, 9302.
in *straungë* hond and thus I tellĕ yow alle, 9314, 15814, 15867, 17210.
or for that ilk man *schuldë* helpen other, 9327.
your *hertë* hongith on a joly pyn, 9390.
that I schul havĕ myn heven in *erthë* heere, 9521.
o servaunt traitour, *falsë* homly hewe, 9659.
for he couthĕ with it *bothë* hele and dere, 10554.
and how and whan it *schuldë* harded be, 10559.
for his honour as *oft*[*ë*] happeth so, 10906.
or to gret *sorwë* held it in distresse, 11228.
ye schal your *trouthë* holden by my fay, 11784.
of *aventurë* happed hirĕ to mete, 11805.
by ordre as *oftë* herd I my lord neven, 12749.
as *thilkë* holy Jew oure eldres taught, 13779.
therforĕ with *wildë* hors he dede hem drawe, 15044.
o *yongë* Hughe of Lyncoln, slayn also, 15095.
he *couthë* hunt at wildë deer, 15147.
that bereth the *reedë* heepë, 15158.
his *brightë* helm was his wongèr, 15320.
in *allë* hastë cum to me he saydë, 16493.
but er he *haddë* half his cours i-sayled, 16585.

So, when Palamon the larkĕ herdë syngë, 2212.
that is in *mariagë* honey swetë, 9270.
and geve hem *sugrë*, hony, breed, and mylk, 10928.
of every *plantë*, herbë, tre, and flour, 11344.

But in these cases the e might have been preserved, even before a vowel, by cæsura; see § 82.

In v. 8634 the participle, in 8642, 11796, 12919 the infinitive, and in 10439 the preposition (withoutë), should probably have an n; haddë hight, 11822, might possibly be hadde y-hight.

§ 78. It is very probable that some liberty was allowed with regard to elision of e before h. A few cases are added where the practice (so far as it can be determined by a very few examples) seems to have varied, and a few other instances, which, if the reading is correct, are exceptions to § 77.

now wol I speke[n] of my fourth[*e*] housbonde, 6034.
now wol I telle[n] of my fourt[*he*] housbonde, 6062; but fourthë, 6035, 6085, 6169; y-had fyve housbondes, 5599, should probably be, had *fyvë*.
the thrid[*de*] hour inequal that Palamon, 2273.
fyve houres for to slepe upon a night, 14512.
But, the *nextë* hour of Mars folwynge this, 2369.

that is to seyn, trouthe, honour, and knighthede, 2791.
of the bodyes and the grete honour, 999.
(grete, 11399, should be gret.)
that verray neede unwrappeth al thy wounde hyd, 4523.
bothe halle and chambur ylik [in] herĕ degré, 8139.
and that he woldĕ come hastily ageyn, 11151.
and eek the clernes[*se*] hool of sapience, 12039.
bothe harp and lutë, gitern and sauterie, 17200.

§ 79. An accented final e (including e coming from French é, even when the accent has been cast back) is of course not elided.

and yet hath lovĕ maugré here eyghen two, 1798.
he wolde noon auctorité alegge, 9532.
of pité on this sike Damyan, 9853.
the beauté of the gardyn and the welle, 9910.
til Canacë hath in hir lap[*pe*] ytake, 10789, etc.

§ 80. The **e** of monosyllables is commonly not elided, except in the case of the article **the** and the negative particle **ne**.

ne that a monk whan *hë* is cloysterles, 179.
and in his armes *hë* hem alle up hente, 959.
he may not *flë* it though he schuldĕ be deed, 1172.
and *seë* his lady wel neih day by day, 1409.
so send *më* him that most desireth me, 2327.
al *bë* it that it *bë* agayns his kynde, 2453.
which that *schë* hath, i-wis I werĕ to nyce, 10308, etc., etc.

But, me athinketh that I schal reherce it heere, 3170.

§ 81 *a*. The **e** of **the** is much more frequently elided than not, and before **e** almost invariably. The consonant is frequently united to the following word.*

but to the effect, it happed on a day, 1191.

* So also with the verb the = thrive, in the forms theek, theech, 3862, 12857, 14362.

this is *th*effect of his entente playn, 1489.
*th*enchauntements of Medea and Cerces, 1946, 1958, 2279, 4570, 5385, 7778, etc.
that is bitwixe *th*est and eek the west, 6829.
*th*estat, *th*array, the nombr*e*, and eek the cause, 718.
that hath the sight of hir and I th*e* absence, 1241.
than was *th*assemblé of this blisful oost, 4823, 3078, 7463, 13619, etc.
he wolde mak*e* a fyr in which *th*office, 2865, 2914, 4893.
and eek also, wherso he saugh *th*ymage, 14916.
of brend gold was the caas and eek th*e* herneys, 2898.
of children to *th*onour of God above, 9323, 14988.

On the other hand: —

wost thou nat well *thë* olde clerkes sawe, 1165, 6444, 10520, 12105.
that al *thë* orient laugheth of the light, 1496, 452.
up to *thë* ancle they faught in herĕ blood, 1663, 419.
the fyres brenden on *thë* auter bright, 2427, etc., etc.
only *thë* intellect withouten more, 2805.
of which *thë* eldest hightë Algarsyf, 10344?
men may *thë* eelde (qu. olde?) at-ren, but nat at-rede.
thë elf-queen with hir jolly compaignye, 6442.
but al for nought; *thë* end*e* is this, that he, 6652.

b. The **e** of **ne** is perhaps less frequently elided.

and whan a best*e* is deed, he n*e* hath no peyne, 1321.
allas I n*e* havĕ no langagĕ for to telle, 2229, 7501.
n*e* abydë no man for his curtesye, 3125.
n*e* at Romë for the harmĕ thurgh Hanibal, 4710.
privé n*e* apert, thay wolde never fine, 6718.
I n*e* held me never dign*e* in no manere, 8694.
I n*e* hav*e* as now no leiser morĕ to seye, 11289.

On the other hand: —

në oynëment that wolde clens*e* and byte, 633.
në of the knobbes sittyng on his cheekes, 635.
no berd *në* hadde he ne never scholdë have, 691.
that ther nys water, erthë, fyr, *në* eyr, 1248.
in al the routë nas ther young *në* old, 3112.
në in noon other placë never the mo, 9963.
in al the world *në* hadde be thy peere, 15540.
if that the wynd *në* hadde be contrarie, 16555, 10174.

§ 82. The cæsural pause frequently prevents the elision of final **e**.

a. that on his schynë — a mormàl hadd*e* he, 388.
this was thyn othë — and myn eek certayn, 1141.
withouten doutë — it may stonde so, 1324.
and let*e* him stillë — in his prisoun dwelle, 1337.
but how sche didë — I ne dar nat telle, 2286.
for thilke peynë — and that hootë fuyr(e), 2385.
som*e* hadde salvë — and som*e* hadde charmes, 2714.
and tyl he haddë — al that sight i-seyn, 4377.
than that it rotë — al the remenaunt, 4405.
ir*e* is a sinnë — oon the gret*e* of sevene, 7587.
to stond*e* in gracë — of his lady deere, 13276.
if that a princë — usë hasardrie, 14014.
no lenger thannë — after Deth thay sought[e], 14187.

b. the trespas of hem bothë — and herĕ cause, 1766.
I prey to God hir savë — and susteene, 4580.
for though that I be foulë — old and pore, 6645.
com forth my swetĕ spousë — out of doute, 10018.
in thend*e* of which an uncë — and no more, 13194.
this Persoun him answerdë — al at oones, 17324.

§ 83. Other vowels are occasionally elided, as in modern verse.

for unt*o* a poor*e* ordre for to geve, 225.
ne was not worthy t*o* haven an office, 294.
and wher the*i* engendrid, and of what humour, 423.
and certes, lord, t*o* abiden your presence, 929.
b*y* eterne word to deyen in prisoun, 1111.
and he hem graunted merc*y*, and thus he sayde, 1830.
unto his bod*y* agayn, and he awook, 7285.
how might a man hav*e* en*y* adversité, 9212.
and I wil fondĕ *t*espien on my syde, 9284.
right in this wis*e* he to Placèb*o* answerde, 9394.
fro which *t*escapë woot I no socour, 11669.
tel us a talë, for thou canst man*y* oon, 13734.
to tell*e* a stor*y* I wil do my labour, 14874.
this wer*e* a popet in an arm t*o* embrace, 15112.

SILENT FINAL e.

§ 84. E final seems especially liable to become silent when it follows **r**.

The sound **r** is peculiarly unstable, and most languages, in their successive stages or in their dialects, afford instances of its being transposed, now standing before, now following a vowel, as Saxon gaers, græs; Ital. capre, Roman dial. crape; Eng. iron, apron, spectre, etc. In Wright's text of the *Canterbury Tales* we often find the terminations **re** and **er** indifferently used, as asondre, 5577, asonder (ur), 7256 f, 493 f. Of course we have no means of determining to what degree, if at all, the pronunciation er had begun to prevail even while the spelling re was retained. The Comparative Degree of Adjectives is commonly spelled with er in Chaucer (see § 38, *a*), instead of the Saxon re, though both forms occur; as bettre, 526, 650, better, 10416 f; lenger, 332, lengere, 823. Nouns which anciently ended in -ere generally or always end in -er, as hopper, 4034, miller, 3923, sleper, 16377, etc. (See § 8.) We find many French words spelled both with re and er, as lettre, 5228, 5229, 5241, letter, 10415 f; cloystre, oystre, 181, 182, cloyster, oyster, 7681, 7682; chambre, 1073, chambur, 13145; tendre, 150, 9631, tender, 9617, etc. We also find the final e of some French words absolutely dropped; thus maner occurs most commonly without a final e, except at the end of a verse, 71, 2546; 10501 f, 11737 f; ryvèr (F. *rivière*) is rhymed, 6466, with bachelèr (F. *bacheler*), and 15148, with deer; cheer (F. *chère*) once, 1342, with prisonèr (Fr. *prisonnier*), though commonly pronounced cheerë. In these cases ryvèr must have been pronounced like our revere (ryve-er) and cheer che-er, instead of ryvèr-ë, cheer-ë, the r being in fact transposed.

§ 85. The only rule with regard to e being silent after r which can safely be made general, is perhaps that

e final is silent in the pronouns

hirĕ, here (S. hire, E. her), 123, 128, 134, 461, 472, 474, 475, etc., etc.; very often spelt hir, see 16313, 16329.

herĕ (S. hira, E. their), 11, 32, 1018, 1639, 1805, 2321, 2322, etc., etc.

ourĕ (S. ûre), 34, 921, 1110, 1284, 12599, 12600, 13140, 14259, 14429, 14480, 14480, 14518, etc., etc.

yourĕ (S. eôwer), 772, 785, 806, 831, 919, 922, 929, 1106, 1306, 1315, 1871, etc., etc.

ourë, 6111, 6177, 14248, and yourë, 16414, are decidedly doubtful.

§ 86. **ere**: — e final is frequently silent in *were*.

were (Indic. 2d pers. sing.), 15866, 15888, 17177.
" (plural of Indic.) 18, 26, 59, 81, 2169, 2185, etc., etc.
" (Subjunctive), 584, 877, 1213, 1216, 14229, 14570, etc.; written wer, 10782, 16280 (ner = ne wer).

But not in the following cases: —

werë (Indic. 2d pers. sing.), 4877, 16718.
" (plural of Indic.), 326, 1705, 1966, 6893, 12838, etc., etc.
" (Subjunctive), 9483; 10529 may be read, and it werĕ good that such thing were y-knowe; or, and 't werë good that such thing werë knowe.

§ 87. There can be no doubt, however, that e final was *generally* pronounced after r. It is commonly in the body of a verse, and for metre's sake, that the occasion is presented for dispensing with this sound; rarely is it dropped for the sake of rhyme, though very often e is added on that account to words which ordinarily terminate in a consonant, — or, more properly speaking, of two existing forms, a rarer one in -e is often employed when the rhyme demands the final vowel, as yer by *yere*, 4552, rhyming with *heere*.

The final e of *deere* (S. deôre) and of *cheere* (Fr. chère) was most distinctly pronounced. We should therefore be justified in inferring that the final e was pronounced in the following words, rhymed with deerë and cheerë, even if this fact could not be independently proved, as can be done in the case of most of the instances cited.

deerë, 1236, 2455, 3361, 4238, 7363, 7405, 8932, 15056, 16833, 17206.
The only exception noticed is 7334.

Therefore,

heerë (adverb), 1821, 3502, 3774.

prayerë, 2261, 12184.

cheerë, 749, 5422, 8411, 8554 (cheer, 8889, in a suspicious line).

Therefore,

heerë, 7884, 8245.

yerë, 8278.	
in feerë, 4815, 12308.	in feerë, 4815, 8989.
steerë, 4868, 5253.	
frerë, 6881, 13283.	frerë, 6847, 7739.
manerë, 7207, 8455.	manerë, 140, 10821.
to leerë, 7098, 13277.	leerë (verb), 10418.
cherë, 8017, 12232, 12310.	deerë, 14739, 14836.
matierë, 8198, 8467.	materë, 729, 15409.
werë (subj.), 8758.	
to heerë, 8963.	to heerë, 915, 2900.
cleerë, 12182, 15066.	cleerë, 8655, 9719.
beerë, 15091.	berë, 6169.
(to) appeerë, 13060.	to repeirë, 14737.

On the same principle:—

feerë, 2346, 2688, 2932, 7286, 16877.	beerë, 15036, and above.
Therefore,	Therefore,
eerë, 6603.	werë, pl., 2901, 15662.
terë, 11206, 15664.	terë, 15664.
gerë, 5220.	
therë, 5222.	therë, 15037.

eerë, 6218, and above (S. eârë).

Therefore,

werë, pl., 8604, 12823.
werë, subj., 17131.
therë, 7650.
wherë, 7634, 10629.

§ 88. Less to be relied on are the following:—

sperë, 15289 (S. sperë): therefore,
berë (*ursus*), 1642.
werë (plural), 2950.
to berë, 4877.
to derë, 10554.

teerë (see above): therefore,
werë (pl.), 4954, 11493, 15544, 15662.
therë, 4956.
werë (2d person), 16146.
scherë, 15542.
yerë, 15545.
enquerë, 9417.

scherë (S. scearë): therefore (?),
werë (pl.) 15544.
yerë, 15545.
teerë, 15547.

gerë? (S. geara), 367: therefore,
werë (subj.), 353.
werë (plural), 1017.
therë, 5222, 8250.

enquerë (Old Fr. enquerre), 9406? therefore,
enquerë, 3166.
therë, 3165.

requerë (Old Fr. requerre), 6634? therefore,
therë, 6633.

Fynesterë (Fr. Finisterre), 410? therefore,
werë (plural), 409.

{ merë (*equa*), 543. { mellerë? 544.

{ forberë, 3168. { myllerë? 3167.

§ 89. On the other hand, we find many cases in which **e** final must have been silent, or where it is actually dropped, after **er**; as,

berĕ (*ferre*), 1424,
berĕ (*ursus*), 2060,
berĕ (*fero*), 8760,
werĕ (*vestiri*), 8762,
swerĕ (*jurare*), 11101, 12076,
} rhymed with the pronoun herĕ, hirĕ.

So, answerĕ, 9744.
baner (N. Fr. baniere), 980.
beerĕ, 6179.
berĕ, 2762, 9918, 12264.
chambrĕ, 9696.
deerĕ, 7334; 15538?
ferĕ, 11172.
frerĕ, 208, 7315;
but frerë, 7252, 7254, 7258, 7264, etc.
maner, 71, 2546, 3681, 8395, 16332, etc.
swerĕ, swer, 456, 8045, 8238.

Note.—For the double forms here, her; there, ther; where, wher; evere, ever; see § 72, *b*.

Herĕ, 1645, 14400, 14401, 12294 f, might as well be written *her:* so, also, in 4023, 10989, where it stands rhymed with peere (N. Fr. *peer, pair*), which word again, in those places, and also at 16336, where it is rhymed with Chaunteclere (Fr. *Chantecler*), and even 15540, where it is rhymed with deere, should, I apprehend, be written, as at 12907, peer. Chauntecler is mostly misspelt, as above, in the *Nonnes Prests Tale*. That it ought to have no final e appears from the French derivation, and from the rhymes ber (*tuli*) and powèr (N. Fr. *poueir*), 16822, 16830; also misspelt bere, powere.—*Ever*, 12802, should be evere, to correspond with dissevere.

§ 90. With regard to final **e** after **ir**, **ar**, **or**, **ur**, it does not appear to be more frequently silent in such cases than after other letters, except in *sire* and *more*.

sirĕ (N. Fr. sire), 9542, 12527, 13030, 13035, 16274, 16428, 16516, etc.; sir, 7056.	sirë, 16253 (but Tyr. has "good sirĕ"); 357, rh. schire.
irĕ (S. yrre), 7575; 7671? rh. squire (Fr. esquier, and spelt elsewhere squier).	irë, 14072, 1764, 1661, 7593, 17210, 17220.
	barë, 9225, 685 f, 16099 f.
	fairë, 234, 884, 1687, 2596, 2665, 4021, 12043, 12060, etc.
	sparë, 739.
	charë (Fr. *chaire*), 16099.
declarĕ, 14893, *extremely* doubtful.	declarë, 7061 f, 14939 f.
	hairë, 14151.
	peyrë, 2123.
morĕ, 98, 827, 976, 1124, 2742, 7453, 7679, 9372, 9489, 13219, 14791, 14842. mor, 7485, 10648, 16255.	morë (S. mâre), both adjective and adverb, 306, 785, 1577, 2826, 4049, 4050, 9107, 14563; 804, 3222, 3519, 6023, 6313, 9110, 13352, 14560, 15774, 16790, 16813, 16915, 17072.
porĕ, 4536, 4540, 16308.	porë, 232, 480, 490, 539, 704, 13594, 14128, 16307.
biforĕ, 9602, 14995.	byforë, 379 f, 3238 f.
sorĕ, 2697, 3462.	sorë, 230, 1396, 12657, 12799.
dorĕ, 552, 3471, 3482.	dorë, 1989, 3435, 3499, etc.
therforĕ, therfor, 777, 7374, 10571, 10647.	therforë, 3506 f, 8035 f, 9023.
	fourë, 2141, 3883, 13388.
vesturĕ, 10373.	purë, 1281, 12016.

§ 91. A considerable number of cases will now be given of **e** silent after other letters than **r**, without any attempt to explain the fact.

a. **e** silent after **l**, **m**, **n**.

allĕ, 210, 348, 779, 937, 946, 979, 4541, etc.
hallĕ, 9962, 10400.
talĕ, 13875.
tellĕ, 38, 10043.
hellĕ, 660.
fellĕ, 2112.
wellĕ, 8091.
felĕ, 9332, 9338.
melĕ, 4051, 4068.
welĕ, 4542, 8350, 8847.
soulĕ, 658, 14355, 14399.
myllĕ, 4019.
mylĕ, 14102.
pylĕ, 6944.

damĕ, 4571, 4604, 5152.
madamĕ, 7786, 7792.
namĕ, 14864, 15128.
claymĕ, 9176.
demĕ, 3194.
comĕ, 689, 14184.
welcomĕ, 764, 856, 7382, 7393.
somĕ, 9345.
tymĕ, 9678, 10327, 10790, 12976, etc.

pan', 1167, 15438.
regnĕ, 1626.
clenĕ, 12228.
begynnĕ, 17347.
nonĕ, 1066.
sonĕ, 6733, 7655, *and almost always.*
gounĕ, 93.

b. **e** silent after **w**, **y**.

dawĕ, 10069.
schrew', 7024.
trewĕ, 10043.
bowĕ, 2897.
crow', 17172.
ynowĕ, 4675.
trowĕ, 526, 1803, 3665, 9092, 9111, 10850, etc.
widow', 6609, 6626, 7166, etc.
morwĕ, 824.

joyĕ, 9929.
weyĕ, 34.

c. **e** silent after **p, b, v**.

helpĕ, 10773.
felawschipĕ, 476, 430; worschip, 12560.
hopĕ, 88, 9548.
popĕ, 6002.

havĕ, 888, 909, 921, 1257, 2774, 9210, 9277, 9308, 10371, 10594, 10853, 11359, 11456, 11530, 14140, 14142, *and almost always.*
savĕ, 7289, 7449, 7857, 13717, 14133.
avĕ, 14919.
recyvĕ, 9576.
levĕ, 5694, 9330, 9715, etc.
givĕ, gevĕ, 223, 7455, 7456, 7457, 9401, 9403, 14319.
lyvĕ, 9157, 14258.
stryvĕ, 7568.
lovĕ, 1137, 1756, 1807, 2226, *and almost always.*
grovĕ, 1690.

d. **e** silent after **k, g, ch**.

sakĕ, 539, 1319, 1802.
seekĕ, bisekĕ, 7251, 14109.
spekĕ, 9742, 9747.

mariagĕ, 9550, 9560, 9663.
viagĕ, 794.
visagĕ, 630.
agĕ, 13445.
tongĕ, 10349.
bringĕ, 10049.
segĕ, 15865.

spechĕ, 16978.
wrechĕ, 16089.
chirchĕ, 3984.

e. **e** silent after **t, d, th**.

(Besides the final e of the Imperfect Indic. of Simple Verbs, which is as often silent as pronounced.)

hatĕ, 13640.
betĕ, 383.
getĕ, 9819.
metĕ, 136, 345, 9795, 10384.
swetĕ, 2782.
hertĕ, 8062, 9113, 10526, 16301.
schertĕ, 748, 2548, 6768.
might', 1789, 2237, *and always.*
sight', 3395, 7653, etc.

forbedĕ, 9635.
dedĕ, 14926.
heed', 7483.
ledĕ, 9308.
redĕ, 14208.
steedĕ, 10438.
endĕ, 197.
fyndĕ, 15408.
kyndĕ, 5263, 11080.
lyndĕ, 2924.
holdĕ, 9364.
housĕ-bondĕ, 8574.
fondĕ, 9284.
woodĕ, 2932, 7755, 10727.
lowdĕ, 15024.
bruyd', 9694.

byquethĕ, 2770.
mirthĕ, 9613.
rewthĕ, 10752.
trouthĕ, 10959, 11071, 11905.
youthĕ, 9612.

f. **e** silent after **s (c)**.

nosĕ, 123, 705, 2169.
prosĕ, 466.
clennessĕ, 508.
besynes, 13140.
goodnes, 7395.
lewednes, 10537, 12415.
worthines, 2594.
goddessĕ, 930.
blis', blys', 1686, 4453, 4842, etc.
wisĕ, 2189.
cheesĕ, 3628.
supposĕ, 8223.
thesĕ, thisĕ, 9110, 9127, 9150, 9297, 10041, etc.
praysĕ, 9420.
pres' (Fr. presse), 10503.
nobles', 15504.

gracĕ, 1175, 6842.
forcĕ, 3910 (but forcë, also in the same line).
princĕ, 4642.
malicĕ, 8950, 9098.
placĕ, 15024.
Constauncĕ, 4698, 4858, 4866, 4986 (but Constauncë, 4684, 4851, 5320, 5527).

Many words of French origin are spelt in Chaucer sometimes with a final ce, sometimes with s, as:

experience, 7099 f.	experiens, 5583, 10112 (6050, rh. with defens, which in old French is spelt both with and without a final e).
plesaunce (Fr. plaisance), 8840 f.	pleisauns, 8749.
norice, 5881.	noris, 8494.
pacience, 1085 f.	paciens, 16312.
sentence, 308 f, 14974 f.	sentens, 17352.
forcĕ, 3910.	fors (rh. cors), 17000.

solas, solaas, solacĕ (N. Fr. solas) is rhymed with caas, allas * (N. Fr. cas, alas), Nicholas, was, 800, 3654, 9149, 11114, 16689.
solace with place (N. Fr. place), 4144, 15193.

allaas and laas (N. Fr. las) are rightly written, 2391.
lace and trespace (N. Fr. trespas), wrongly (?) 1819.

trace (N. Fr. trace, trasse) and allas are rhymed, 1953.
trays and harnays (N. Fr. harnas, harnois), 2141.

face (N. Fr. face) and trespace are rhymed, 9701.
faas (face) is even rhymed with the English haas (has), 13117; and gras (grace) with Thopas, 15242.
prefas (Fr. préface) occurs 12199.

§ 92. For convenience' sake the final e in the above citations has been treated as silent. It is, however, a question, and a question which may be called at least a *difficult* one to solve, whether the e in many cases was absolutely dropped, or only slightly pronounced. In very many lines the verse would be equally agreeable, whichever of the two should be done; in some, the verse might be fuller to a good ear, if the e were slightly sounded; in some, this sound would disturb the metre.

A considerable number of these exceptions might disappear on a comparison of manuscripts, but very many would doubtless remain. The vowel appears to be most frequently silent after the liquids, after w and v, t, d, and s.*

Possibly, all that is to be said of this matter is, that the final e might be dropped freely, as in modern German verse, as: —

> das Erst' wär' so, das Zweite so.
> der begehrt jede liebe Blum' für sich,
> und dünkelt ihm es wär' kein Ehr',
> und Gunst die nicht za pflücken wär'.
> hat er so aller Treu', so aller Lieb' vergessen,
> etc., etc. — (Goethe's *Faust.*)

Of course we are not authorized, in the present state of our knowledge, to drop the superfluous e and indicate the omission by an apostrophe.

* las (from lassus) was, in the older French, variable according to the sex of the person uttering the exclamation; as, lasse! fait ele: halas! fait-il. Palsgrave has both forms also. The distinction is not preserved in Chaucer, but the diversity in the spelling of the word may possibly be owing to the existence of these two forms. Not so with the other words cited.

* Some of the most noticeable words are the pronouns *hire*, *here*, *oure*, *youre*; the verb *were*; then *sire*, *more*, *alle*, *tyme*, *sone* (filius), *trowe*, *have*, *give*, *love*, *sight'*, *woode*, *bliss'*.

CONTRACTIONS.

§ 93. The **e** in final **er** is very frequently elided, especially under the circumstances in which final **e** would suffer elision.

after (=aftr): and *after* that, Amor vincit omnia, 162.
his breed, his alĕ, was alwày *after* oon, 343.
he waytud *after* no pompë ne revĕrence, 527.

anger (=angr): nis ther no morë woo, në *anger*, në ire, 12847.

answer (= answr): the *answer* of this I letë to divines, 1325.

begger (= beggr): he was the beste *begger* in al his hous, 252.

coper (= &c.): he put this unce of *coper* in the croslet, 13236.

delyver: and wondurly *delyver*, and gret of strengthe, 84.

ever, never; and *ever* honoùred for his worthinesse, 50.
withoutë bakë metĕ was *never* his hous, 345.
that *never* ye schullen my corounë dere, 1824.
as I cam *never*, I can nat tellen wher, 2812.
ne in noon other placë *never* the mo, 9963.
So, 1262, 8020, 8027, 9605, 9618, 10077, 10078, 15753, etc., etc.

fader: schuld letë *fader* and *moder* and folwë me, 5613.

fether: as eny raven *fether* it schon for blak, 2146.

fynger: with Goddis *fynger*, and Eli wel ye witen, 7472.

maner: in *maner* of a compleÿnt or of a lay, 9755.

nedder: lyk to the *nedder** in bosom sleighe untrewe, 9660.

neyther: *neyther* man ne best such as men can devyse, 9413, 9962.

ofter: if thou bigilĕ me any *ofter* than oones, 16914.

over: that executeth in the world *over* all, 1666, 11967.

persèver: I will persèver, I am not precious, 5730.

silver: he bar alwày of *silver* a smal cliket, 32.

ther nas *quyksilver*, litargë, ne brimston, 631 (?).

sober: but thay ben sobre that for the pepul pray, 7484.

somer: the hootë *somer* had maad his hew al broun, 396.

sowter: or of a *sowter* a schipman or a leche, 3902.

togider: and gaderud us *togider* alle in a flok, 826.

water: by *water* he sente hem hoom to every land, 402, 3815, 13244.

whether (= wher): I not *whether* sche be womman or goddesse, 1103, 15415.

wher sche be wys, or sobre, or dronkelewe, 9407, ii. 339, 344.

let se *wher* thou canst tellen ought in gest, 15341.

wonder: ye wolde *wonder* how wel and thriftily, 12531.

§ 94. The vowel is elided under similar circumstances in the syllable **-en**.

men *mooten* (moot?) *given* silver to the porë freres, 232.

ful longe *wern* his leggus and ful lene, 593.

weren of his bitter salte teeres wete, 1282.

whan that we *comen* ageyn from Canturbery, 803, 896.

and forth we *riden* a litel morĕ than paas, 827.

i-fetered in his *prisoun* for evere moo, 1231.

we *faren* as he that dronke is as a mows, 1263.

and though that I no *wepen* have in this place, 1593.

they brennë, sleen, and *bringen* hem to meschaunce, 5384.

* Should perhaps be neddre (S. nædre), but, as before said, re and er are interchanged.

and up they *risen*, a ten other a twelve, 10697.

children an heep *y-comen* of Cristen blood, 14908.

§ 95. The third person singular of the Present Indicative ends commonly in **-eth**, not seldom in **-th**. When the form in **-eth** is used, the **e** is often elided.

This Palamon *answereth*, I graunt it the, 1622.

and *thenketh*, here *cometh* my mortel enemy, 1645.

bounté *cometh* al of God, nought of the streen, 8033, 14196.

makth for his wyf and for his child also, 5318, 7415.

thapostil whan he *spekth* of maydenhede, 5646.

who *clappith* ther, sayd this widow, benedicite (bencite), 7166.

thus in delyt he *lyveth*, and hath don yore, 7944.

he by the hond than *takith* this oldë man, 8178, 5562.

honoùreth hir, and *loveth* hir, I yow pray, 8246, 8247.

and *spedith* yow fastë, for I wol abyde, 9801.

but Canacè hom *bereth* hir in hir lappe, 10949.

the pot *to-breketh*, and far wel, al is goo, 12835.

abideth, for Goddes dignë passion, 14396 (*abidth*, etc.).

§ 96. Miscellaneous Contractions.

his *purchasyng* might nought ben to him suspect(e), 322.

a *schirrevë* hadde he ben and a counter (schrivë), 361 (?).

in al the parisshë wyf ne was ther noon (parsshë), 451.

wyd was his *parisch*[*e*], and houses fer asondur, 493.

the ferrest in his *parisschë*, moche and lite, 496.

to fightë for a lady, *benedicite* (bencitë), 2117.

what rounĕ ye with hir maydenes, *benedicite*, 5823.

out of here oughnë hous, a, *benedicite*, 5862.

So, 7038, 7166, 7752, 9211, 12556.*

and certeynly wher naturë wil not wirche (certnly?), 2761.

a man to light a *candel* at his lanterne (candl), 5916.†

freres and feendes been but *litel* asonder (litl), 7256.

* We may therefore infer a lacuna in 1787:
the god of lovĕ, —— a benedicite.

† So candlestick (canstick) in Shakespeare, 1 Henry IV. 3. 1 (Guest, I. 54: canstick in the quartos).

trillë this pyn, and he wol *vanyssh* anoon (vansh), 10642.

thus hath this *widow* hir litel child itaught (widw), 14920.*

thou *woldist* han be a tredë-foul aright (woldst), 15431.

but sire, I dede it in no *wicked* entent[e] (wickd), 16909.†

§ 97. Cases like the following, in which contiguous words are blended, are not common in Chaucer, but there is no reason to suspect the correctness of the lines.

for him was lever have at his (at's) beddeshead, 295.

a swerd and a ('n a) bocler baar he by his side, 560.

I ne (I n') saugh this yeer so mery a companye, 766.

we moste endure it (endur't), this is the schort and pleyn, 1093.

whethir it (wher't) be by desteny or adventure, 9841.

Contractions of the various kinds noticed in §§ 93–97 are on the whole not so frequent in Chaucer as in Shakespeare and Milton: see very numerous examples in Guest's *English Rhythms*, B. I. C. III.

MISCELLANEOUS NOTES.

§ 98. Letters.

a. **ch**, for the Saxon **c** (**k**), before or after e, i, occurs in several cases where modern English has retained the primitive sound.

seche (=seek), 786, 7537, 7539.
recche (=reck), 1400, 5911.
wirche (=work), 2761 f; worche, ii. 379, iii. 143.
thenche (=think), 3253 f.
yliche, liche (=like), 7797, 10376 f.
ich (=ik, I), 10037, and in theech, 12857, 14362.

So, rubriche (=rubric, Fr. *rubrique*), 5928 f.

On the other hand, k is often preserved in Chaucer where we have substituted ch; as, biseke (=beseech), 7251, ii. 379, etc.

b. Saxon **g** is changed to **w**, instead of **y**, **i**, as in modern English, in dawes (=days), 11492; fawe, from S. *feah*=*faegen*, fain, 5802 f; i-slawe=slain, 14271, 16500: so wawe (S. *wæg*), 4888=Eng. wave.

c. **th** is dropped after **t**, or changed to **t**, in the following contracted forms: —

wiltow (wilt thou), woltow, 1546, 6422.
hastow (hast thou), 3534, 3538, 11893.
wostow, 3544.
slepistow, 4167.
herdistow, 4168.
artow, 4728.
hydestow, 5890.
schaltow, 6998.
atte beste (at the beste), 29.
atte siege, 56.
atte fulle, 653.
atte laste, 2828.
atte boord, 10393.
atte halle, 10394, etc., etc.

d. The letters **r** and **s** were unstable in the older English, and subject to frequent metathesis. In the transition to modern English these letters have changed their position more than once in some words, e. g.: —

berstles, 558; S. *bristl*, Mod. E. bristle.
brid, 17104; S. *bridd*, E. bird.
brast, 2612; breste, 2613; S. *berstan*, E. burst.
brent, 948; brenne, 17161; S. *byrnan*, *brinnan*, E. burn.
carte, 2043; S. *craet*, E. cart.
crispe, 2167 (crips, *House of Fame*, iii. 296); S. *cirps*, *crisp*, E. crisp.
crulle, 81; E. curl.
kers, 3754; S. *cerse*, *cresse*, E. cress.
thirled, 2712; (nose-) thurles, 559; S. *thyrlod*, *thyrel*, E. thrilled, (nos) trils.
thridde, 14251; threttene, 7841; thritty, 14437; S. *thridda*, etc., E. third, etc.
throp, 8075, 8084; S. *thorp*, E. -thorp, -throp.
thurgh, 1098; S. *thurh*, E. through.

axe, 1349, 12354; axyng, 1828; S. *ascjan*, *acsjan*. aske, 3557.
crispe, S. *cirps*, see above.

* Similar forms, though not contracted, are sorwe, 1456; wilw, 2924; morw, 9622.

† This is an unusual contraction, but by no means unparalleled; thus,

> Why, fool! says Venus, thus provokst thou me,
> That being *naked* thou knowst could conquer thee?
> Crashaw (ed. Turnbull), p. 123.

lipsede, 266 ; E. lisped.
clapsud, 275 ; E. clasped.

§ 99. Accent. — Many words of French origin have two accents ; sometimes on the final syllable, or the penult; sometimes thrown further back, as in English.

bataìlle, 990, 2404.	bàtail, 2099, 2542.
benìgne, 520, 8973.	bènigne, 8287.
discrèt, 8286.	dìscret, 520.
fortùne, 917, 1240, 1254, 13710, 16172, 16209.	fòrtune, 927, 1244.
honèst, 14972.	hònest, 246.
laboùr, 14874.	làbour, 8093, 12705.
natùre, 11, 10667, 13710.	nàture, 10801, 13424, 13444.
povèrt, 4519, 6767, 6773, 8692.	pòvert, 6749, 6761, 6765, 13856.
prayèr, 2269, 2334.	prèyer, 2423.
prisoùn, 1177, 1272, 1453.	prìsoun, 1087, 1109, 1238.
resoùn, 37.	rèsoun, 1768, 4639.
servìse, 2489, 1805.	sèrvise, 122.
squyèr, 79, 1732.	sqùyer, 1500, 1556.
vertùe, 4, 14882.	vèrtu, 1438, 2751, 8092.
victòrie, 2241, 2407, 2435.	vìctorie, 874, 2422.

Examples of the French accent : —

ther nas discòrd, rancoùr, ne hevynessë, 8308.
glori and honoùr, règnë, tresòr, and rent(ë), 15697.

So, Aprìlle, Averìl, 1, 6128.	Àpril, 4426.
Arcìta, Arcìte, 1114, 1128, 1147, 1350, 1395, 1527, 1530, 1542, 2860, 2941, etc.	Àrcita, Àrcite, 1154, 1346, 1598, 2258, 2423, 2690, etc.
Cresùs, 16245.	Crèsus, 1948, 16213.
Grisìldes, 8108, 8131, 8211, 8304, etc.	Grìsildes, 8086, 8173.
Noè, 3534 f.	Nòe, 3539, 3560.
Platò, 13376 f, 13384, 13388.	Plàto, 13381, 13391.
Venùs, 1906, 2223 f.	Vènus, 1920, 1939, 1951.

So, also, with the nouns of Saxon derivation, in -ynge, yng (see § 17) :

and felàwe, fèlaw (see § 18) :
mellère, myllère, 544 f, 3167 f ; mèller, 3923, 3993, 3998, 4008 :
yemàn, 6962, 12612, 12629 ; yèman, 101, 6977, 12555, 12580.

§ 100. Syntax for Measures, Kinds, etc. — *a.* Nouns denoting a substance measured, weighed, or numbered are not put in the genitive, as in modern English; but are in apposition with the noun denoting the measure, etc. (as in Saxon sometimes, and in German regularly).

a peyre dys (G. ein Paar Würfel), 4384, 14038.
a peyre plates, 2123.
a barel ale (G. eine Tonne Bier), 15379.
a botel hay (G. ein Bund Heu), 16946.
a busshel whet, 7328, 4310.
half a quarter otes, 7545.
the beste galoun wyn, 16956.
a morsel bred, 15920.

b. Nouns denoting sort or kind are in like manner followed, not by the genitive, but by a noun in apposition (as also in German).

a maner deye (G. eine Art Milchfrau), 16332.
a maner sergeant, 8395 ; so, 3681, 11742, 11745.
no maner wight, 71, 2546.
what mestir men, 1712.
no kyn monay, 14749.

c. Nouns denoting measures of various kinds are not put in the plural after a numeral (as also in German).

syn thilke day that she was seven night * old, 16359 ; this fourtënight, 931 ; thritty winter * he was old, 14437, 15545, 7233 ; a child of twelf month old, 14895 ; foure yer,* 8487, 8612, 13445.
twenty thousand scheld, 14763.
fourty pound, 7688, 13289.
fyvë mylë, 12483 f.
an hundred thousand del, 17069.

d. Sometimes numerals preceded by the article **a** are treated like nouns, the thing numbered being put in the plural number, but still not in the genitive case (compare, a few pears, a great many men, a dozen books).

* Night and winter (S. niht, winter) have commonly the plural like the singular in Saxon (instead of nihta, wintras), but this is not a peculiarity of inflection : it is a consequence of a principle of syntax. Year (S. gear) might have the plural like the singular at any rate : still the cases cited are fair instances of the rule. Fortnight (fourtënight, 931) has become a compound noun, and so has twelvemonth (a twelve moneth, 653), but these forms properly come under *c* and *d*.

(of florins fyn) wel neygh *a seven bushels*, 14186.
a twenty bookes, 296, Tyr. (the right reading).
a twenty thousand freres, 7277, Tyr. "
hir maistres clepeth *wommen a gret route*,
and up they risen, *a ten other a twelve*, 10697.

According to the same principle,

a certein frankes, 14745 ; a certeyn yeres, 15663.
a certeyn *of* conclusiouns occurs, 3193.
a certeyn gold, 14815.

§ 101. Genitive Case. — *a.* Of Genitives employed as adverbs we have these cases: —

his thonkes (S. his þances), 1628, 2109.
here thonkes (S. hira þances), 2116, iii. 186.
his willes (S. his willes), 5854.
needes (S. nêdes), 1171, 7887, 10179, etc.

b. The Genitive sign is not annexed to a compound phrase, as in English; thus,

the wyves love of Bathe (= wife of Bath's love), 9046.
by my modres Ceres soule (= my mother Ceres's soule), 10139.
Goddes sone of hevene (= God of heaven's son), iii. 101.

c. The Genitive of names of persons and titles of books is sometimes used as a nominative: as, Cerces, 1946; Judicum, 15532; as saith us Eneydos, 16845.

§ 102. Dative Case. — *a.* After *to be.*

wel was him, 2111.
yow is better, ii. 338.
the is better, ii. 345.
wo were us, 8015.
wo is him, 14421, 10892.
(wo was his cook, 353.)
me is wo bygoon, 11628.
(wo was this womman bigoon, 5338.)
ther is the schapen of thy wo an ende, 1394.
or be him loth or leef, 1839.
if that yow be so leef, 14175.
loth were him, 488.
loth hir was, 11903.
him was lever have, 295.
the were lever, ii. 339, 16955.
N. B. { *him hadde* lever, 3541.
al *had hir* lever han had, 8320. }
(have I lever, 11672; I hadde lever, 15379.)

b. After verbs of motion, as in Saxon.

goth him, 3434, 4060, 13622; 14748.
went hir, 4213, 9653, 13038.
he rydeth him, 1693.
stalked him, 8401.
hy the, 13223?
up styrt hir Alisoun, 3822?

c. After other verbs.

they dreden hem (as in Saxon), ii. 352.
ne drede the nought, 12252.
(sche) falleth him to feete, 5524.
stele hem (from them) half a pekke, 4008.
us thoughte (it seemed to us), 786, etc.

§ 103. Pronouns. — Personal Pronouns.

me, for I, once; can hem therefore as moche thank as *me*, 1810.
his, genitive of it; *his* officĕ naturel ay wol it holde, 6726.
but lokë that it have his spokes alle, 7838.
it am I, it am nat I, as in Saxon and German (for it is I, S. ic hit eom), 1462, 1738, 3764, 5529, 14625.
he in the sense of *one*, indefinite, iii. 184, 186; (his = one's), iii. 123, 125, 126; (him), iii. 185; (her, plural), iii. 184; so, himself, 7589.

he, she, redundant, with proper names.

he Simplicius Gallus, 6225.
he Theodomas, 9594.
he Jakke Straw, 16880.
to slen him Olefernes, 5360.
of hir Philologie and he Mercurie, 9608.
so, 9912, 10564, 6080, 9242, 9247, 16627, etc.

Both (as in German) follows, and does not precede, the genitive of the personal pronoun, as *here bothe* lawes, 4641, etc.

§ 104. Relative and Interrogative Pronouns.

a. That is frequently used in conjunction with the pronoun *he* (in a manner resembling the German idioms, *ich der ich*, I that, *Du der Du*, thou that), so that both together express only the relative pronoun, as: —

a knight ther was, and that a worthy man,
that from the tymë that he ferst bigan

to ryden out, *he* lovede chyvalrye, 45.
al werĕ they sorĕ hurt, and namely oon,
that with a sperĕ was thirled *his* brest boon, 2712.
I saugh today a corps y-born to chirche,
that now on Monday last I saugh *him* wirche, 3430.
among thesĕ children was a widow sone,
that day by day to scolë was *his* wone, 14915.

Without the personal pronoun: —

I have a brother, quod Valirian tho,
that in this world I lovë no man so, 12164.*

So, without *that*: —

and to be bounde undur subjeccioun
of *oon* sche knew nat *his* condicioun, 4691.

b. Which frequently has the signification of *what, what sort of* (like *welch* in German); as, *which* a miràclë [ther] bifel anoon, 2677.

So, 40, 2950, 3611, 5621, 6875, 10896, 11754, 16065.

c. Which (*the which*) is often redundant, as in the following phrases: —

the place *which* that I was inne, 10891, iii. 122.
hem *whiche* that wepith, ii. 330, 348.
his love *the which* that he oweth, iii. 110.

d. What is used for why, like Latin *quid*, German *was*: —

what schulde he studie and make himselven wood? 184.
what schulde I alway of his wo endite? 1382.

e. What is used in an indefinite sense (like German *etwas, was*) †: —

wite ye what? (= wissen Sie was?) 10305, 17014.

f. Whoso is frequently used in the sense of *if any one*.

eke Plato seith (who so that can him rede), 743.
is wryten, God woot (who so cowthe it rede), 4615.
for craft is al (who so that do it can), 9890.
Herodes (who so wel the story sought), 13903.

§ 105. Indefinite Pronouns.

a. Peculiar uses of *one*: —

ire is a sinnë, *oon the grete* of sevene, 7587.
sche was *on the fairest* under sonne, 11046, 8088.
so wel arraied hous *as ther was on*, 11499.

b. Peculiar use of *ought* (like the German *etwa* = *forte*): —

can he *ought* telle a mery tale or tweye? 12525.

§ 106. PREFIXES. — The prefixes *for-* (Ger. *ver-*, Lat. *per-*, *con-*) and *to-* (Ger. *zer-*, Lat. *dis-*) have not lost their force in Chaucer. The following are some examples of their use: —

for-pyned, 1455.	for-kutteth, 17272.
for-do, 1562, 14538.	for-kerveth, 17272.
for-drunken, 3122, 4148.	for-trode, iii. 92.
for-thinketh, 9780.	for-slowthith, iii. 143.
for-druye, 10723.	for-sluggith, iii. 143.
for-fered, 10840.	for-lesith, iii. 155.
for-brosed, 16100.	for-letin, iii. 175.
to-hewen, 2611.	to-tore, 12563.
to-schrede, 2611.	to-breketh, 12835.
to-broken, 2693.	to-tere, 13889.
to-skatrid, 7551.	

§ 107. NEGATIVE SENTENCES. — Chaucer follows the Anglo-Saxon practice with regard to negatives, which was (like the Greek) not, as in modern English, to negative the *copula* only, but to give a negative character to as many words as were susceptible of being thus affected. Two negatives are perhaps more common than one, and verses can often be restored to good metre by restoring a *ne* which has been dropped.

he *ne* was *nought* gay, 74.	*ne* trist him *never*, II. 342.
ther *nys no* more to seye, 1124.	*no* thing schame *ne* hadden, iii. 105.
ne been *not*, ii. 240.	

ther *nas no* dore that he *nolde* heve, 552.
he *never* yit *no* vilonye *ne* sayde,
in al his lyf, unto *no* maner wight, 71.

* Mr. Guest considers the relative in these cases to be a nominative absolute, equivalent to *respecting which*, &c., and cites from Shakespeare an instance closely resembling this last.

Her frights and griefs,
Which never tender lady hath borne greater.
Winter's Tale, II. 2.

The low English of the present day use *which* in a variety of unaccountable ways, and Mrs. Gamp's talk in *Martin Chuzzlewit* is in this particular perhaps not exaggerated. "I know a lady which her name, I'll not deceive you, is Harris," — "If she had abuged me, being in liquor, which I thought I smelt her wen she come," — are phrases similar to the last two of Chaucer's.

† So apparently, at first, in the colloquial "I'll tell you what (Ich will Ihnen was sagen)": but the emphasis put on the *what* shows that it is not now regarded as indefinite.

he *nas no* fool *ne no* demoniak, 7874.
I wol *no* thing *ne nil no* thing certayn, 8522.
that *neyther* in halle, *ne* in *noon* other hous,
ne in *noon* other place, *never* the mo
he *nolde* suffre hir to ryde or go, 9964.
ne for prayer *ne* for meede he *nyl not* be corrupt, iii. 90.
ne wol *nought* spare *no* wight for praier *ne* for gift, iii. 90.
ne God *ne* knowe thay *not*, iii. 167.
ne I *ne* say *not*, iii. 180.
ne for *noon* harm that men doon *ne* sayn, he *ne*
eschaufith *nought* agayns resoun, iii. 140, etc., etc.

But = only takes a negative before it, as in Saxon and vulgar modern English; as,

I *nam but* deed, 1124.
(al the sorwe) *nys but* a litel thing, iii. 91, 179.

§ 108. Various Particles.

As, with the fundamental meaning of *considering, with respect to, so far as concerns*, is employed by Chaucer in various shades of distinctness and strength, decreasing to insignificance.*

and born him wel, *as* in so litel space, 87.
I most *as* now forbere, 887, 7899, 12872 (cf. German *alsdann?*).
this nobil king, *as* to my wit (had &c.), 5623.
(nought I desire) *as* for myself, 7557.
that ye to me assent *as* in this thing, 8370.
as by conjecture (hem thought, &c.), 8282.
(unto such a worthi man) acorded not, *as* by his faculté, 244.
therwith he was, *as* to speke of lynage, 7947.
no lenger may the body of him sojourne
on thorisonte, *as* in that latitude, 9671.
I have had my world *as* in my tyme, 6055.
ye mosten be ful derne *as* in this caas, 3297, 3385, 6947, 7107.
I am unknowen *as* in this contré, 6979.

As in supplicating phrases is often absolutely redundant.

(Goddes of maydenes) *as* keep me, 2304.
(this grace I praye the) *as* sende love, 2319.
(every wight I prey) *as* deme nat, 3172.
(freend so deere) *as* lene it me, 3775.

* A similar loose use of *as* is now reviving.

(I pray to al this companye) *as* taketh nought agreef, 5773.
(for Goddes love) *as* chese a new request, 6642.
(I yow biseke) *as* suffrith me, 7253.
(for Goddis sake) *as* beth of better cheere, 7883.
as voucheth sauf to give me, 8761.
(but thilke God) *as* kepe my lord, 11201.
as preyeth hire so grete a flood to bringe, 11371.
as doth me right, 13581.

[and also in the following:—

pay me, quod he, or by the swet seint[*e*] Annë,
as I wol bere away thy newë pannë, 7196.]

In like manner *so* is redundant, in one instance:—

for love of God *so* doth your selvë grace, 10772.

as is used as a relative in this one case: there may be more, but others have not been noted:—

his hundred *as* I spak of now, 1860.

by in the sense of *about*:—

allĕ this ensamples tel I *by* this men
that ben untrewe, and nothing *by* wommen, 17120.

erst (followed by *than*) in the sense of *before*:—

schapen was my deth *erst than* my schert, 1568.
longe *erst than* primë rong of eny belle, 14077.
(without than.)
for never *erst* ne saugh sche such a sight, 8212.
er than also occurs.
er than the pot be on the fuyr y-do, 12827.

first is once used in the same way as *erst*:—

I loved hire *first then* thow, 1157.

how that, in the sense of *however that, although*:—

how that ignoraunce be moder of alle harm, certis negligence is the norice, iii. 146.

inwith, in the sense of *within*:—

this purs hath sche *inwith* hir bosom hud, 9818.
the piry *inwith* your armes for to take, 10216.
considered hath *inwith* his dayes olde, 9268.

long on (S. gelang), in the sense of *along of, because of*:—

som sayd it was *long on* the fuyr-makyng, 12850.
I cannot tellë wher*on* it was *long*, 12858.

noon, in the sense of *no* (= not):—

whether ye wol or *non*, 11090, iii. 105, 108.
and if that he encreesed were or *noon*, 14492.
(tel me) is he a clerk or *noon*, 12544, iii. 105.

outher — other = either — or (S. oððe — oððe), 1595, 1596, iii. 109.
other = or, 9157, 10697, 13730, 13731.
outher — outher — or, 13077, 13078.

that expressing entreaty, like French *que:* —
mercy, and *that* ye not discover me! 9816.
ne *that* thy talë make us for to slepe, 7890. (?)

ther in the sense of *where*, 172, 224, 249, 7042, 8696, 10812.

til in the sense of *unto:* —
I wol the lede unto the Pope Urban.
til Urban? 12234: so, 1480, 7348.

unto in the sense of *until:* —
and evere schal, *unto* myn hertë sterve, 1146.
unto the sonnë gan arise, 5211.

up in the sense of *upon:* —
up peril of [Wright has *on*] my lif, 6727.

uppon for *on:* —
a long surcote of pers *uppon* he hadde, 619.

§ 109. Certain Peculiar Phrases.

after souper, used as a noun (like afternoon).
at after souper, 10616, 11531: so *at after mete*, 9795.

can thank = scire gratias, savoir gré, 1810, 3066.

do = cause, make.
sche that *doth* me al this wo endure, 2398.
and som tyme *doth* Theseus hem to rest, 2623.
ne *do* no force of dremes (make no account), 16427.

So in the sense of *cause to be* (like the German *lassen*).
(the children) he *dede* gelde, 15638.
do me drenche (have me drowned), 10075.

So again, with the addition of *let*.
he *leet* the fest of his nativité
don cryen . . . 10360.
let do him calle, 13588.

gesse, in the New England sense of *think*.
who so wel remembrith him of these tydinges, I *gesse* his synne schal not torne him to delit, iii. 91.
al be thay grevous synnes, I *gesse* thay ben not dedly, iii. 119.

go = walk (like German *gehen*).
wher I ryde or go (a very common phrase in old poetry), 2254.
he noldë suffrë hir to ryde or *go*, 9964, 7175, etc.
(his felaw was *go walkid* in the town, 7360, must be a bad reading; Tyrwhitt has *y-walkid*.)

much in the sense of *great*.
moche and lite (great and small), 496.
for the *more* part (greater part), 2826.
in his *moste* pryde (greatest pride), 897.

nale, atte = at the ale-house, occurs, 6931.

schal in the original sense of *owes, is bound to*.
so faren we, if I *schal* say the sothë, 12590.
folowe hire wille in al,
as any lover to his lady *schal*, 11062. (?)

(More distinctly in the sense of *owes*, if the reading is correct, and there is no ellipsis, in *Court of Love:* by the faith I *shall* to God, v. 131).

slyde, let, in the modern sense.
well neigh al othir cures *let he slyde*, 7958.

sworn, apparently in the sense of *sworn the contrary*.
som wikke aspect or disposicioun
of Saturne, by sum constellacioun,
hath geven us this; *although we hadde it sworn*,
so stood the heven whan that we were born, —
we moste endure it . . . 1089 – 1090.
and walk I wold, as I had don biforn,
fro hous to hous, *although he had it sworn*, 6222.
unneth[e] trowed thay, but dorst *han sworn*,
that to Janicle, of which I spak biforn,
sche daughter were (i. e. *was not*), 8279 – 81.

The same phrase (*although we had it sworn*) is ambiguous in 12609.
Though al the world had *the contràry swore* occurs, 10639, 1668.

the, definite article, with abstract noun.
thexperiens wot wel it is not so, 5706.
thexperiens so preveth every day, 10112. (?)
experiens without the article, 5583.

these, curiously used somewhat like the Latin *iste*, but in a fainter sense.
thesĕ wormes, [ne] *thesĕ* moughtes, ne *thesĕ* mytes,
upon my perel fretith hem never a deel, 6142, 3.
wher as *thesĕ* robbours and *thesĕ* theves by kynde, 12587.
So, 10961, 10962, 12995.

wear on, upon = wear.
and *wered upon* my gay scarlet gytes, 6141.
that *werith on* a coverchief or a calle, 6600.

who was who occurs, 4299.
but sikirly sche wistĕ nat *who was who.*

§ 110. Peculiar Order of Prepositions.

whan these trespasours and *repentynge folk of here folies* . . . hadden herd what the messangeres sayden, ii. 381.
doth *digne fruyt of penitence*, iii. 85.
But, — doon workes worthy of confessioun, iii. 87.
ye *lerned men in lore*, 14389.
ye, for an hairë clout to *wrap in me* (me in), 14151.
(fader hath he non) that I *of woot* (wot of), 5441.
of al this thing which that I *of havĕ sayd*, 7827.
a long surcote of pers *upon* he *hadde* (had on), 619.
with *kempe[d]* heres *on* his browes stowte (hair combed on), 2136.
sche was wel morë blisful *on to see* (to look on), 3247.
ourĕ *ground(e)* litarge eek *on* the porfurye (litharge ground on), 12703.
to doon al that a man *bilongeth unto* (belongs to a man), 9333.
som what *to quyte with* the knightes tale (requite the tale with), 3121.
to *helë with* your eyen (heal your eyes with), 10246.
to *helen with* this hauk, 10955.
to *blynde with* this prest, 13079.
that no goodnes ne hath to *paye with* his dette, iii. 98.

§ 111. Ellipsis.

Of the *relative pronoun.*

there was non auditour [*that*] cowde on him wynne, 596.
and in a purs of silk [*that*] heng on his schert, 9757.
a pyn [*that*] stant in his ere, 10630.
he sent after a clerk [*that*] was in the toun, 13555.

Of *to* before the Infinitive.

now is tyme [to] wake al night, 3672.
he was worthy [to] have his lif, 6627.

Of the *personal pronoun*, when subject.

us thoughte it nas nat worth to make it wys,
and [*we*] graunted him withoutë more avys, 787.
this thing was graunted, and [*we*] oure othus swore,
with ful glad herte, and praÿden him also, 813.
ye, false harlot, hast [*thou*]? 4266.
(than schal he knowe al her harlotrye); ye, schal [*he*]? 10138.

Of *be.*

that is, or schal [*be*], whil that the world wol dure, 1362.

Of *have.*

he wold hir [*have*] hent anoon, 3347.

Of *it.*

ner gingling of the bellis (*were it not for*), 16280.
nere myn extorcions, I might not lyven, 7021.

APPENDIX.

It will not be out of place to add to these notes a few citations, exemplifying such of the principal points in Chaucer's language as have not been already illustrated in that way. In so doing, the order of verses has been followed, and the points intended to be illustrated are indicated by numbers referring to the foregoing sections.

Verse.		Section.
129.	ne wett*e* hirĕ fyngres in hirĕ saucĕ deepĕ.	85, 19, 69.
230.	he may not wepĕ, though him sorĕ smertĕ.	60, 69, 56 *a*.
456.	I durstĕ swerĕ they weyghedĕ ten pound(e).	89.
610.	he cowdĕ bettrĕ than his lord purchacĕ.	53 *a*, 60.
673.	that streyt was comen from the court of Romĕ.	19.
	ful lowd*e* he sang, Com(*e*) hider, lovĕ, to me.	12.
822.	we dronken, and to restĕ went*e* echoon.	55, 17.
956.	him thoughtĕ that his hertĕ woldĕ brekĕ.	53 *a*, 4, 60.
1221.	how gret a sorwĕ suffreth now Arcitĕ!	16, 19.
	the deth he feleth thorugh his hertĕ smytĕ:	4, 60.
	he weepeth, weyleth, cryeth pitously.	50.
1299.	and eek with peynĕ that lovĕ me geveth also.	91 *a*, 91 *c*, 95.
1612.	hav*e* heerĕ my trouthĕ, to morw*e* I nyl not faylĕ.	89, 91 *c*, 60.
1616.	and ches the best, and lef the worst for me.	58 *b*, 36 *b*.
1805.	herĕ wages and herĕ fees for herĕ servisĕ.	85, 19.
2306.	chastĕ godessĕ, wel wost thou that I.	19.
2521.	som sayd he loked grym, as he wold fight.	53 *b*.
2807.	gan faylĕ whan the hertĕ feltĕ deth.	60, 4, 53 *a*.
2847.	yit ther ne lyvedĕ never man, he seydĕ.	53 *a*.
2960.	ne how the lichĕ-wakĕ was y-holdĕ.	14, 4, 61.
3095.	com neer, and tak your lady by the hond.	58 *b*, 17.
3557.	askĕ nought why, for though thou askĕ me.	58 *a*, 56 *a*.
3699.	my fayrĕ bryd, my swetĕ cynamomĕ,	30, 29 (or 32), 19.
	awakĕ, lemman myn, and speketh to me.	58 *d*.
3726.	havĕ doon, quod sche; com of, and speed the fast[ĕ].	91 *c*, 58 *b*.
4049.	the morĕ queyntĕ knakkes that they makĕ,	38 *b*, 52 *c*.
	the morĕ wol I stelĕ whan I takĕ.	38 *b*, 60, 48.
4052.	the grettest clerks beth not the wisest men.	35 *a*.
4300.	but as sche saugh *a whit* thing in hir yĕ, }	2.
	and whan sche gan *this whitĕ* thing aspyĕ. }	32, 60.
4649.	saveth my lyf, and beth nat recheles:	59.
	goth, geteth hirĕ that hath my lyf in curĕ.	59, 19.
5010.	sche woldĕ do no synnĕ by no weyĕ.	53 *a*, 16, 14.
5590.	and allĕ werĕ worthy men in herĕ degré.	91 *a*, 86, 85.
5859.	motĕ thi wicked neckĕ be to-brokĕ.	56, 3, 61.
5947.	o levĕ sirĕ schrewĕ, Jhesu schort(ĕ) thy lif.	91 *c*, 90, 3, 91 *e*.
6015.	com ner, my spousĕ, let me ba thy cheekĕ.	58 *b*, 19, 4.
7017.	I sparĕ not to takĕ, God it woot.	48, 60.
7026.	but, levĕ brother, tellĕ me thy namĕ.	34, 58, 3.

7056.	ful many a causë, lievë sir sompnour.	19, 34, 90.
7070.	if that him listë stondë ther agayn.	56 *a*, 60.
7133.	herkë, my brother, herkë by thi faith.	58.
7481.	no drynkë which that dronkë might hem makë,	14, 61, 60.
	but ther in abstinencë prey and wakë.	19, 60.
7593.	I couth*e* of irë seyn so mochë sorwë,	7, 30, 16.
	my talë schuldë lastë til to morwë.	11, 56 *b*, 60, 14.
7655.	his sonĕ was slayn, ther is no morĕ to say.	12 (91 *a*), 90.
7696.	for who can tech*e* and werken as we connë.	60, 52 *c*.
7728.	in hopë for to fyndë ther a giftë.	3, 60, 16.
7908.	hightë this clerk, whos rethoriquë swetë.	53 *a*, 19, 29.
8082.	but heighë God som tymë sendë can	30, 3, 60.
	his grac*e* unto a litel oxë stallë.	3, 14.
9108.	God schildë that it scholdë so byfallë.	56 *b*, 56 *a*, 60.
9215.	ther may no tongë tell*e* or hertë think[ë].	4.
9475.	hir freischë beauté and hir agë tendrë.	30 (or 32), 20, 19.
9504.	that no wight with his blissë parten schal.	17, 60.
9521.	that I schal havĕ myn heven in erthë heerë.	91 *c*, 4, 69.
9768.	whan that the heighë massë was i-doon.	30 (or 32), 4.
9859.	though he no morë haddë than his schertë.	38 *b*, 56 *b*, 16.
9876.	and subtilly this lettrë doun sche thrustë	19, 53 *a*.
	under his pylow, red*e* it if him lustë :	53 *a*.
	sche takith him by the hond, and hard him twistë,	53 *a*.
	so secrely that no wight of it wiste,	53 *a*.
	and bad him be al hool, and forth sche wentë	53 *a*.
	to January, when that he for hir sentë.	53 *a*.
9919.	save he himself, for of *the smalë* wyket	32.
	he bar alway of silver *a smal* cliket.	
10133.	unto this oldë, blindë, worthy knight.	32.
10330.	him lakked nought that longed to a kyng.	53 *b*.
10484.	his steedë which that schon as sonnë bright.	3, 4.
10823.	that no wight wendë that he couthë feynë.	17, 53 *b*, 60.
10987.	quod the Frankeleyn, considering thin youthë,	16.
	so felingly thou spekest, sirĕ, I aloue the.	
11091.	for in this world certein no wight ther is.	17.
11843.	as of the trewest and the bestë wif.	35 *a*, 33.
12221.	saydë this blisful fairë maydë deerë.	53 *a*, 35 *c*, 15, 29.
12590.	so faren we, if I schal say the sothë.	52 *b*, 14.
	now, quod our*e* ost, yit let me talkë to the.	19, 60.
12621.	hold now thi pees, and spek no wordës mo.	58 *b*, 22.
12664.	that whil I lyvë schal I quitë never.	48.
12798.	but that good hopë crepeth in ourĕ hertë,	3, 85, 4.
	supposing ever, though we sorë smertë.	69, 56 *c*.
12991.	at yourĕ comaundëment, sirĕ, trewëly.	85, 90, 71.
13132.	and whan this alcamister saugh his tymë,	3.
	rys up, sirĕ prest, quod he, and stondë by me.	58 *b*, 90, 59 *b*.
13485.	for al to soonë may sche lernë lorë	69, 60, 16.
	of boldënessë whan sche is a wyf.	16.
13700.	therefor*e* I redë yow this counseil takë,	48, 60.

	forsakith synn*e*, er synnë yow forsakë.	59 *a*, 16, 56 *a*.
14233.	what schuldë we than do? what schuld we say?	55 *b*, *c*.
14340.	cometh forth anon, and knelith her adoun.	59 *a*.
14858.	my lady Prioressë, by your levë,	19, 16.
	so that I wist I scholdë yow not grevë,	56 *b*, 60.
	I woldë demë that ye tellë scholdë	53 *a*, 60, 56 *b*.
	a talë next, if so werĕ that ye woldë.	10, 86, 56 *b*.
15024.	so lowdë that al the placĕ bigan to ryngë.	91 *e*, *f*, 60.
15037.	unnethë might the peoplë that was therë	69, 19, 72 *b*.
	this newë Rachel bringë fro the beerë.	60, 16.
15109.	approchë ner, and lokë merily.	58.
	now warĕ you, sirĕs, and let this man havĕ spacë.	90, 91 *c*.
15287.	his bridel as the sonnë schon,	4.
	or as the moonë light.	3.
15599.	thurghout the widë world his namë ran.	17, 3.
16309.	bisyd*e* a grovë, stondyng in a dalë.	14.
16421.	for fer*e* of berës, or of bolës blakë,	22, 40.
	or ellës blakë develës wol hem takë.	73, 40, 22, 60.
16704.	the samë nightë thurgh the heggë brast.	32, 17, 7.
16792.	he mostë wynkĕ, so lowd*e* he woldë crien.	53 *a*, 60.
17270.	in mochel specchë synnë wantith nought.	4.

XVIII.

Plantæ Wrightianæ e Cuba Orientali, Pars II. (Monopetalæ et Monocotyledones), a

A. GRISEBACH.

(*Read April* 22, 1862.)

RUBIACEÆ.

Genipa Caruto, Kunth. Santa Catalina de Guantanamo. (336, 1619, fructif.)

Catesbæa Grayi, Griseb. (n. sp.): foliis elliptico-subrotundis obovatisque spinas sæpe excedentibus; floribus parvis pedicellatis; pedicello calycem (lineam longum) subæquante; calycis lobis deltoideo-acutis tubum subæquantibus corolla multoties brevioribus; corolla subtetragona (4 – 5 lin. longa), lobis ovato-subrotundis obtuse apiculatis tubo ter brevioribus; antheris faucem haud excedentibus; bacca subglobosa. — Syn. *C. parviflora* Sw. ex parte? sec. descriptionem, non Griseb. Fl. Ind. Occ. p. 317. Icon Sloanei a Swartzio citata melius ad *C. parvifloram* Griseb. (*C. parvifoliam* DC.) quadrare videtur: sed ex specimine Swartziano a nobis non viso tantum dijudicari potest, an nomenclatura Candolleana restituenda sit. Pedicelli quaque in *C. Grayi* sæpe longiores sunt (1 – 2 lin. longi): Cl. De Candolle vero qui *C. parvifloræ* Sw. specimen originale viderat, et huic et *C. campanulatæ* Ram. flores dicit sessiles et, an utraque distinguenda sit, dubitat. Speciei a cl. Ramon de la Sagra nominatæ specimen in herbario Hookeriano vidi, quod ad *C. parvifloram* meam pertinet, unde, Swartzium eandem habuisse vel *C. Grayi* non distinxisse, judicavi. "Frutex orgyalis, baccis albis: in sylvis ad Monte Verde." (371.)

Randia aculeata, L. (392.)

Sphinctanthus longiflorus, Griseb. (n. sp.): foliis spathulato-oblongis obtusiusculis; corollæ tubo longissimo (7 – 8 lin. longo) cylindrico basi leviter incrassato limbo ante anthesin subuliformi octies longiori; antheris subsessilibus; stigmatis lamellis plano-ovoideis; drupa ellipsoidea. — *Conosiphon aureus* Poepp. (1845) ex ic. congener, sed *Sphinctanthus* ann. 1844 descriptus est. "Frutex 6 – 8-pedalis: in sylvis prope Monte Verde. Corolla tubo viridi, limbo albido." (1263.)

SCHRADERA CEPHALOPHORA, Griseb. (n. sp.): foliis oblongo-ovalibus; stipulis spathulatis petiolum subæquantibus; capitulis terminalibus solitariis pedunculatis; involucro integerrimo calyces dimidios æquante; corolla hypocraterimorpha, tubo cylindrico calyce duplo longiori, lobis 6 lanceolato-linearibus tubum subæquantibus; staminibus inclusis corollæ tubo medio insertis; stigmate bifido. — Proxima *S. cephaloti* Vahl., Jamaicensi, staminibus inclusis distincta. "Prope Monte Verde, arbores excelsas scandens; flores albi fragrantes." (1264.)

HAMELIA PATENS, Jacq. (227.)

HAMELIA LUTEA, Rohr. (234, 1265.)

HOFFMANNIA? LANCEOLATA, Griseb. (n. sp.): glabra; foliis subcoriaceis lanceolatis vel elliptico-lanceolatis acuminatis in petiolum attenuatis; cymis in glomerulum pauci – uniflorum axillarem pluribracteatum reductis petiolo superatis; floribus sessilibus; calycis limbo quadripartito, segmentis deltoideis. — Folia 3 – 2 poll. longa, 8 – 12 lin. lata, petiolo 3 – 6 lin. longo. Calyx 2 lin. longus. Corolla ignota. Bacca globosa, bilocularis, seminibus obovoideis 3 – 5 in quoque loculo maturantibus. Habitu *Hoffmannia psychotriæfoliæ* (*Higginsia*, Benth.) affinis, calycis limbo profundius diviso a speciebus melius notis differt. "Frutex debilis, in pinetis prope Monte Verde," etc.: flores albi: baccæ atropurpureæ. (253.)

GONZALEA PETESIA, Griseb. (*Petesia spicata*, Sw.) (233.)

COCCOCYPSELUM REPENS, Sw. (257.)

CHIMARRHIS CYMOSA, Jacq. "Ad Monte Verde, etc. Stipulæ glandulis linearibus intus donatæ. Flores albi, diœcio-dimorphi, aut staminibus exsertis stigmate incluso, aut stylo exserto antheris inclusis." (1262, 1622.)

EXOSTEMMA LONGIFLORUM, R. & S. "Flores virginei albi, dein rosei." (265.)

EXOSTEMMA ROTUNDATUM, Griseb. (n. sp.): glabrum; foliis ovali-rotundatis (3 – 2 poll. longis) in petiolum brevem basi attenuatis; corymbis paucifloris; pedicellis calyce breviter cylindrico longioribus; calycis dentibus subulatis obtusiusculis tubo plus duplo brevioribus; corolla tubo cylindrico (20 – 22 lin. longo) lobis fere duplo longiori; capsula oblonga lævi (10 lin. longa). "In pinetis prope Monte Verde. Arbor gracilis 20 – 30-pedalis. Flores viriduli, dein albi, demum rosei et rubri." (1258, 1259.)

EXOSTEMMA ELLIPTICUM, Griseb. (n. sp.): glabrum; foliis ellipticis (2 – 3-poll.) breviter petiolatis; floribus corymbosis, pedicellis calycem breviter cylindricum subæquantibus; calycis dentibus subulatis tubo duplo brevioribus; corollæ tubo cylindrico (pollicem longo) lobos subæquante; capsula oblonga obtuse costata. — "Arbor sat alta, in sylvis prope Monte Verde, floribus albis dein roseis." (1257.)

EXOSTEMMA VALENZUELÆ, Rich. Cub. t. 48. Ramuli apice parce puberuli: folia

elliptica, subtus in axillis venarum piliferis: corymbi densiflori: capsula minuta, obovato-oblonga. Forsan *E. parviflorum* Rich. non differt. "Frutex, floribus albis suaveolentibus. Ad Monte Verde." (1260, 1261.)

Portlandia gypsophila, Macf., Griseb. Fl. Ind. Occ. p. 324. (259.)

Hillia tetrandra, Sw.! (266.)

Hillia longiflora, Sw. (1256.)

Calycophyllum candidissimum, DC. — Staminum insertione, quod cl. Klotzsch negabat, cum *Warszewiczia* convenit, nec recedit nisi calycis limbo truncato et inflorescentia. (258.)

Ferdinandea stellata, Griseb. (n. sp.): glaberrima; foliis 3 – 4-natim verticillatis spathulatis obtusis coriaceis; corymbis specialibus 3 – 5-floris, pedicellis calyce longioribus; calycis dentibus minutis deltoideis; corollæ tubo gracili clavato limbo calyceque 3 – 4-plo longiori, lobis subrotundis; antheris oblongis inclusis; capsula obovata (semipollicari); ala seminum oblonga sublacera. — "In pinetis prope Monte Verde. Arbor humilis; flores atrorubentes." (264.)

Ferdinandea brachycarpa, Griseb. (n. sp.): ramulis puberulis; foliis ternatim verticillatis lanceolato-oblongis apiculatis coriaceis subtus puberulis glabratisque ad nervos pubescentibus; corymbis sub-9-floris in thyrsum oblongum dispositis; pedicellis brevibus; calycis segmentis ovatis obtusis; flore . . . . .; capsula globosa ad commissuram contracta (lin. 3 diam.); seminibus minutis ala laciniata subrotunda cinctis. — "In fruticetis prope Santa Catalina." (1621.)

Rondeletia (Eurondeletia) buxifolia, Vahl. (262.)

Rondeletia (Stevensia) Poitæi, Griseb. *Stevensia buxifolia*, Poit. (1266.)

Rondeletia (Stevensia) rigida, Griseb. (n. sp.): foliis rigidis ($1\frac{1}{2}$ – 3-poll.) ovatis seu ovato-oblongis acutiusculis basi rotundatis supra impresso-venosis subnitido-glabris subtus in nervatura prominula pube simplici strigosis vel pubescentibus margine revolutis; stipulis subulatis deciduis; glomerulis subsessilibus pube adpressa lanuginosis; bracteis involucrantibus segmentisque limbi calycini ovato-oblongis; corolla extus lanuginosa intus glabra, tubo cylindrico apice dilatato (semipollicari) calycis lobos 5 plus duplo superante. — Affinis *R. incanæ* Sw. "Ad villam La Madelina. Frutex 10-pedalis, foliis ramorum validiorum sæpe ternatim verticillatis, corollæ limbo atrorubente." (1617.)

Manettia coccinea, Willd. *M. cuspidata*, Bert. (267.)

Manettia lygistoides, Griseb. (n. sp.): foliis ovato-lanceolatis lanceolatisque rigidulis glabrescentibus subtus aveniis brevissime petiolatis; stipulis minutis; cymis paucifloris subsecundis foliis superatis; calycis lobis 4 lanceolatis obtusiusculis cum toti-

dem denticulis alternantibus; corollæ tubo breviter cylindrico (lin. 2 longo) calycis limbo duplo longiori ad faucem barbato; antheris inclusis; seminibus ala lata denticulata cinctis. — Habitus *M. Lygisti* Sw., quæ venis foliorum subtus reticulatis, corolla longiori et floris seminumque fabrica differt. "Prope Monte Verde in pinetis. Corolla viridula: antheræ purpuræ." (257.)

Oldenlandia callitrichoides, Griseb. (n. sp.): glabrescens, radicans; caulibus filiformibus diffusis; foliis minutis ovato-orbicularibus in petiolum contractis, imis petiolo brevioribus; stipularum setis minutis vel obsoletis; pedicellis solitariis filiformibus elongatis; calycis dentibus 4 distantibus breviter lanceolatis piliferis; corollæ infundibuliformis lobis tubum subæquantibus; filamentis fauci insertis anthera minuta globosa multo longioribus; stylo ad medium bifido, ramis pilosis; capsula turbinata apice inter dentes calycinos convexa loculicida; seminibus minutis truncato-obovatis scrobiculatis. — Habitus *Hydranthellæ* et affinium Scrophulariacearum, accedit ad *Houstoniam*, e. g. *H. serpyllifolium* Michx., sed ex seminum forma potius *Oldenlandia*, nisi ob styli fabricam generice distinguenda. Folia lineam diametro: pedicelli 4–8 lin. longi. "Ad ripas rivulorum: flores albi." (268, coll. 1856–7. 1640, coll. 1859–60, pro parte.) [Specimina cum iis numeri 378, *Hemianthi*, infeliciter mixta.]

Lucya tuberosa, DC. (269.)

Spigelia Anthelmia, L. (390.)

Guettarda elliptica, Sw.: spec. fructifera. (1609.)

Guettarda calyptrata, Rich. Cub. t. 46. "In montibus prope villam Josephina, etc." (1295, 1618.)

Guettarda bracteata, Griseb. (n. sp.): *Guettardaria;* foliis rigidis obovatis obtusis glabris supra lævibus, venis primariis subtus prominulis; stipulis deltoideo-subulatis; pedunculis trifloris folium sæpe æquantibus; bracteis oblongo-linearibus margine recurvis calycem truncatum subæquantibus; corollæ tubo cylindrico lanuginoso (semipollicari) calycem 5–6-plo superante, lobis 6–5 puberulis obovatis undulatis tubo 3–4-plo brevioribus; drupa globosa (3 lin. diam.) puberula triloculari. — "Prope Monte Verde. Arbor gracilis, 20–30-pedalis. Flores albi mox rubelli." (261, 1292.)

Guettarda reticulata, Griseb. (n. sp.): *Guettardaria;* foliis rigidis elliptico-oblongis obtusiusculis undulato-repandis supra glabris in axillis venarum subtus pilosis inque ipsis hispidulis, venulis utrinque prominulis, quaternariis areolas seriatas subquadratas formantibus; stipulis lanceolato-acuminatis petiolisque rufo-hispidulis; pedunculis pubescentibus folium subæquantibus ejusque ramis abbreviatis 3-(–1-) floris; bracteis subulatis calyce truncato superatis; corollæ tubo cylindrico-clavato lanuginoso (semipollicari) calycem triplo superante, lobis 5 tubo multo brevioribus; drupa ellip-

soidea (lin. 3 longa) pubescente longitudinaliter venis costata triloculari. — Similis *G. membranaceæ* Sw.! ex Haiti, cui corolla filiformis, flores ebracteati et folia laxe reticulata utrinque setuloso-muricata. — "In sylvis Cubæ Orientalis frequens. Frutex vel arbor humilis: flores albi purpureo tincti." (263, 1293, 1294, 1616.)

Guettarda macrocarpa, Griseb. (n. sp.): foliis mollibus ovatis acutiusculis basi breviter cordatis supra velutinis subtus lanato-tomentosis, venis primariis subtus prominentibus; stipulis maximis (pollicaribus) ovato-oblongis petiolum excedentibus; flore . . . . . ; drupa ovoidea (12 – 15 lin. longa), loculis 6 rectis centro putaminis crassi lacunosi approximatis. — Stipulis ad sect. *Ulolobum*, fructu vero ad *Guettardiaram* accedit. "In præruptis prope Monte Verde. Arbor grandis." (1296.)

Stenostomum lucidum, Gærtn. Santa Catalina. (1270, 1620.)

Stenostomum granulatum, Griseb. (n. sp.): foliis spathulato-lanceolatis seu lanceolato-oblongis obtusis breviter petiolatis glabris subtus granuloso-asperiusculis aveniis; stipulis oblongis acutis; pedunculis bifidis folium subæquantibus, ramis ejus recurvatis, floribus valde distantibus ebracteatis; calyce glabro, limbo breviter campanulato truncato in tubum longiorem oblongum contracto; corollæ tubo anguste clavato glabro, lobis 4 parvis; antheris inclusis; stylo exserto; drupa biloculari ellipsoidea calycis limbo mamilliformi coronata. — "Ad Monte Verde. Arbor humilis, floribus albis odoratis." (1271, 1272.)

Chione lucida, Griseb. (n. sp.): foliis lanceolato-oblongis obtusis supra lucidis subtus tenuiter venosis; stipulis deltoideis inferne connato-tubulosis; cymis laxis, floribus alaribus breviter pedicellatis; corolla ad $\frac{1}{3}$ 5-loba staminibus duplo superata; antheris linearibus filamento brevioribus; drupa ellipsoideo-oblonga basi obtusa apice truncata. — "Ad Monte Verde, in sylvis opacis. Arbor humilis." (250, 1238, 1286.)

Chione elliptica, Griseb. (n. sp.): foliis ellipticis obtusiusculis basi breviter cuneatis supra lucidis lævibus subtus tenuissime venosis; stipulis ovato-lanceolatis; cymis multifloris, floribus alaribus subsessilibus; corolla ad medium 5-loba staminibus parum breviori; antheris oblongo-linearibus filamentis brevioribus; drupa oblonga basi ovata apice truncata. — "In sylvis prope Monte Verde. Arbor gracilis, 30 – 60-pedalis, floribus odoratis." (1287, fructif. foliis majoribus, 1288.)

Chione myrtifolia, Griseb. (n. sp.): foliis parvis elliptico-lanceolatis acutiusculis subtus aveniis, venis supra impressis; stipulis parvis subulatis; cymis trifloris, floribus pedicellatis; corolla ad $\frac{1}{3}$ 5-loba; antheris oblongo-linearibus. — "Ad villam La Perla. Arbor humilis." (1289, corolla nondum aperta.)

Erithalis rotundata, Griseb. (n. sp.): foliis ovato-rotundatis basi cuneata in petiolum longiusculum attenuatis; calycis limbo obtuse 5-dentato; corollæ segmentis spa-

thulato-linearibus; antheris (lineam longis) filamento subæquilongis; drupa 5-(–7-) pyrena. — "In præruptis ad Monte Verde. Frutex majusculus, albiflorus." (1267, 1268.)

CHIOCOCCA RACEMOSA, Jacq., *a.* JACQUINIANA. (252.)

CHIOCOCCA NITIDA, Benth. "Ad Monte Verde in pinetis." (1290.)

[COFFÆA ARABICA, L. (251.) Cult.]

FARAMEA ODORATISSIMA, DC. (232, 241, florif. et fructif.)

PSYCHOTRIA ULIGINOSA, Sw. *P. lævis*, DC. "Drupa rubra demum atra." (228.)

PSYCHOTRIA TENUIFOLIA, Sw. "Flores albi." (1282.)

PSYCHOTRIA CORONATA, Griseb. (n. sp.): *Mapouria*, fruticosa vel arborea, glabra; foliis coriaceis ellipticis vel elliptico-oblongis acutis vel obtusiusculis (3–2-poll.) in petiolum longiusculum attenuatis lævibus, venis tenuibus; stipulis inferne connato-vaginantibus ovatis oblongisque deciduis; panicula triradiata cymosa fastigiata; floribus alaribus sessilibus, lateralibus glomeratis vel solitariis; calycis limbo producto ovario longiori, 5-dentato in fructu abruptim tubuliformi; corolla ad faucem villosa, lobis tubo duplo brevioribus; bacca ovoidea, pyrenis 4-sulcatis, cristis convexis, commissura plana. — Ab affini *P. androsæmifolia*, Griseb. (Jamaicensi) differt coronula baccæ lineam longa: Wrightianam legerunt quoque Linden in Cuba (coll. ejus 1774) et Schomburgk in Haiti (ex ejus scheda "ardor parva, quandoque frutex, floribus albis odoris.") [Ex schedis Wrightianis "frutex 4–10-pedalis vel arbuscula."] (1284, 1285, 1385.)

PSYCHOTRIA CELASTROIDES, Griseb. in Fl. Ind. Occ., p. 341. "In sylvis opacis. Frutex gracilis, floribus albis, fructibus flavidis." (237 [in herb. Gray cum *P. lasiophthalma* mixta], 246, 1275.)

PSYCHOTRIA RUFESCENS, Kunth, Bartl. *P. Portoricensis*, DC. (244, 1277.)

PSYCHOTRIA LASIOPHTHALMA, Griseb. (n. sp.): *Mapouria*, fruticosa, glabra vel apice glabrata; foliis chartaceis lanceolato-ellipticis oblongisque acuminatis; stipulis subdistinctis ovato-lanceolatis acuminatis rufo-pilosis deciduis; panicula pedunculata laxa trichotoma, floribus breviter pedicellatis; calyce minute 5-dentato; corolla infra faucem villosa, lobis tubo duplo brevioribus; bacca ovoideo-globosa (sesquilineam longa), pyrenis ad commissuram planis, albumine ibi minute bisulcato. — Affinis *P. hirsutæ* Sw., bacca rotundata stipulisque distincta: folia glaucescentia. "In sylvis ad Monte Verde. Frutex gracilis, floribus albis." (1274, 1626.)

PSYCHOTRIA COSTIVENIA, Griseb. (n. sp.): *Mapouria*, fruticosa, glabra; foliis chartaceis obovato-oblongis vel ellipticis rotundato-acutiusculis longe in petiolum attenuatis, venis costatis 12–15-jugis subtus arcte prominulis; stipulis distinctis ovatis acuminatis sæpe bifidis deciduis, lobis anguste subulatis; panicula pedunculata trichotoma, floribus

glomeratis; corollæ lobis tubo duplo brevioribus; stylo exserto; bacca subglobosa ($2\frac{1}{2}$ lin. diam.), pyrenis ad commissuram planis, albumine ibi bisulcato. — Folia siccata glauco-nigricantia. "Prope Monte Verde, in sylvis opacis. Frutex 3–10-pedalis, floribus albis, fructibus coccineis." (242.)

PSYCHOTRIA TRISPICATA, Griseb. (n. sp.): *Mapouria*, fruticosa, glabra; foliis chartaceis elliptico-oblongis seu ellipticis utrinque acutiusculis; stipulis basi breviter connatis ovatis cuspidato-acutis ciliatis petiolum superantibus deciduis; floribus glomeratis in spicam interruptam simplicem vel basi supra pedunculum simpliciter trifidam dispositis; bacca globosa, pyrenis ad commissuram planis bisulcatis. — "In sylvis prope villam San Andres. Frutex 4–6-pedalis, floribus viridulis, fructibus rubris: folia in axillis venarum superiorum saccato-glandulosa: stipulæ majusculæ carinatæ." (1280.)

PSYCHOTRIA BRACHIATA, Sw. "Flores albi seu viridulo-purpurascentes: fructibus indigoticis." (231 quoad coll. anno 1859, et 1283.)

PSYCHOTRIA HEBECLADOIDES, Griseb. (n. sp.): *Eupsychotria;* ramulis tetragonis pubescentibus; foliis (6-pollic.) membranaceis elliptico-oblongis cuspidatis supra glabris, venis costatis subtus pilosulis; stipulis basi in vaginam truncatam connexis utrinque geminis linearibus petiolo brevioribus persistentibus; panicula thyrsoidea pedunculata, ramulis ejus cymigeris, bracteolis oblongis acutis calycem superantibus; corolla puberula ad faucem villosa, lobis tubo cylindrico triplo brevioribus; antheris linearibus e fauce exsertis; bacca globosa minuta (fere lineam diam.) calycis limbo diviso coronata, pyrenis obsolete 3–5-carinatis, albumine semilunari. — Simillima *P. hebecladæ* DC.! cui bracteolæ lineares, minores. "In sylvis montis Nima-nima. Arbuscula, floribus luteolis." (231, coll. ann. 1856–7, et 1627.)

PSYCHOTRIA PYRAMIDALIS, Griseb. (n. sp.): *Eupsychotria;* ramulis puberulis subtetragonis; foliis magnis (12–6-poll. longis) papyraceis ellipticis breviter cuspidatis basi in petiolum attenuatis pube farinosa minutissima evanida glabratis; stipulis subdistinctis bifidis, lobis deltoideo-acuminatis distantibus vagina truncata æquilongis; panicula pedunculata pseudo-axillari pyramidato-thyrsoidea folia subæquante, ramis ejus scorpioideo-cymosis, bracteolis pluribus ovato-oblongis calycis tubum subæquantibus; calycis limbo 5-partito; corolla parva tubulosa glabra fauci pilosa, lobis tubo brevioribus; antheris linearibus inclusis; bacca subglobosa, pyrenis obsolete 4-cristatis, albumine semilunari. — Habitu accedit ad *P. uliginosam* Sw., sed ex albumine campylospermo ad sect. *Eupsychotriam* referenda, ex proxima præcedenti, cui stipulæ angustiores. — "Prope Monte Verde. Fruticosa, 6–10-pedalis, fructibus atris." (1281.)

PSYCHOTRIA PUBESCENS, Sw. (243, 1278, 1279, 1625.)

Psychotria patens, Sw. "Baccæ cæruleæ." (230 fide A. G., 236, 1276, 1623.)

Psychotria nutans, Sw. (1628, fructif.)

Psychotria parasitica, Sw. (249.)

Psychotria crassa, Benth. [228 ex mscr. Griseb.: sed specimina numeri 228 in herb. Gray omnia ad *P. uliginosam* referenda; *P. crassæ* frustra quæsivi, nisi sub no. 249 cum *P. parasitica* confusa.]

[Psychotria oligantha, DC.?? Specimina imperfecta, fructifera, dubia. 238.]

Palicourea crocea, DC. (229, 245) & β. tenuiflora, Griseb. (247.)

Palicourea alpina, DC. *P. Mexicana*, Benth. (239, 248, corollis hirtis *P. erianthæ* DC.)

Palicourea Pavetta, DC. (240, 1273, 1624.)

Geophila reniformis, Don. (256.)

Machaonia microphylla, Griseb. (n. sp.): spinescens; ramulis puberulis, cymigeris brevibus; foliis subsessilibus parvis (6 – 2 lin. longis) elliptico-spathulatis glabriusculis; stipulis deltoides; cymis simpliciter corymbiformibus laxiusculis pubescentibus, pedicellis calyce turbinato brevioribus; calycis lobis 4 lanceolatis obtusiusculis demum tubo brevioribus; corolla ad medium quadrifida puberula intus pilosa, lobis obtusis stamina duplo excedentibus; filamentis antheræ æquilongis; carpidiis pubescentibus dorso rotundatis ab apice ad basin attenuatis. — Affinis *M. cymosæ* Griseb. (275, 433.)

Diodia rigida, Cham. & Schlecht. (271, 272.)

Spermacoce tenuior, Lam., non Linn. (273, 274.)

Borreria podocephala, DC. (270.)

[Rubiaceæ in coll. 1856 – 7, in exemplis perpaucis divulgatis, a cl. Grisebachio haud visa, sunt —

Randia aculeata, L., no. 391, 392; Randia? fructif., 260; Frutex subtr. Psychotriearum, ruscifolius, fructu baccato dipyreno, 254.]

VALERIANEÆ.

Valeriana scandens, L., var. dentata, Griseb.: foliis subdentatis vel remote inciso-dentatis. (277, 278.) [No. 276 coll. 1856 – 7, a Grisebachio haud visa, est var. indivisa; segmentis lateralibus foliorum præsertim superiorum nullis.]

SYNANTHEREÆ.

Sparganophorus Vaillantii, Gærtn. (279.)

Vernonia menthæfolia, Less.! Species a *Lepidaploa* § 2 apud DC. ad § 1 transponenda. "Fruticosa, scandens, floribus albis." (282, 1305.)

VERNONIA HIERACIOIDES, Griseb. (n. sp.): caule suffrutescente stricto cylindrico scabro; foliis petiolatis ellipticis vel breviter obovato-oblongis cuspidatis remote serrulatis basi obtusiusculis supra glabriusculis impresso-glandulosis subtus puberulis; panicula fastigiata aphylla, ramis ejus glandulo-pilosiusculis dichotomis vel apice brevissime scorpioideis; capitulis subsessilibus 10-floris, extimis sæpe geminis; involucro anguste campanulato (lin. 2 longo), squamis glabriusculis mucronato-acutis patulis, brevioribus pluriserialibus, intimis obtusiusculis; achenio pubescente costato; pappo flavescente, serie exteriori parum latiori brevi. — Habitus *Hieracii Sabaudi*, proxima *V. serratuloidi* Kth., distincta involucri squamis petalis et pappo flavescente. "In pinetis ad Monte Verde." (1306.)

VERNONIA ARBORESCENS, Sw., var. (1309.)

VERNONIA RIGIDA, Sw., var. *V. Sagræana* DC. (284.)

VERNONIA RUBRICAULIS, Bonpl. Equin. t. 99, forma foliis latioribus. [Specimina nec icone nec descriptione Bonplandii congrua!] "In præruptis; flores albi." (285.)

VERNONIA REMOTIFLORA, Rich., forma angustifolia, foliis lanceolato-linearibus. (286.)

DISTREPTUS SPICATUS, Cass. (281.)

AGERATUM CONYZOIDES, L. (1310.)

AGERATUM MUTICUM, Griseb. Fl. Ind. Occ. (1631.)

ADENOSTEMMA SWARTZII, Cass. *Lavenia decumbens*, Sw. (291.)

ADENOSTEMMA TRIANGULARE, DC. "In humidis prope Monte Verde. Flores albi vel purpurascentes." (292.)

EUPATORIUM CONYZOIDES, Vahl. (295.) β. HETEROLEPIS, Griseb. Fl. Ind. Occ. (294.)

EUPATORIUM LANTANIFOLIUM, Griseb. (n. sp.): fruticosum; caulibus cylindricis albo-tomentosis; foliis oppositis petiolo brevi crasso suffultis cordato-ovatis obtusis serrulato-repandis vel integerrimis quintuplinerviis supra rugosis scabris glabratis subtus tomentosis reticulatis epunctatis (2 – 1½ poll. longis); corymbis compactis; capitulis 12 – 24-floris turbinato-hemisphæricis (3 – 4 lin. longis) glomerato-subsessilibus; receptaculo intra squamas involucri producto apice plano; involucro dense lanato, squamis multiserialibus imbricatis plerisque ovatis acutiusculis laxiusculis, intimis longioribus lanceolatis; achenio glabro; pappi pilis apice paullisper incrassatis. — Connectit *Platycephala* cum *Cylindrocephalis*, cum deinceps sequentibus affine est. — "In pinetis et præruptis ad Monte Verde. Flores purpurascentes. Suffrutex 4 – 6-pedalis." (1307, 1308.)

EUPATORIUM PLUCHEOIDES, Griseb. (n. sp.): fruticosum; ramulis cylindricis tomentosis; foliis oppositis breviter petiolatis oblongis basi subcordatis apice acutis vel obtusiusculis serratis vel subintegerrimis penninerviis vel obsolete quintuplinerviis supra

sæpe rugosis scabriusculis subtus tomento evanido pilosiusculis epunctatis (4 – 2 poll. longis); corymbis trichotomis; capitulis 40 – 60-floris turbinato-hemisphæricis (4 lin. diam.) glomerato-sessilibus; receptaculo depresso inter squamas involucri turbinato apice plano; involucro dense pubescente, squamis triserialibus imbricatis lanceolatis obtusiuscule acuminatis subadpressis, exterioribus sensim brevioribus; achenio glabro; pappi pilis apice paullisper incrassatis. — "In sylvis ad Monte Verde. Suffruticosum, subscandens, 8 – 15-pedale, floribus purpureis." (287.)

Eupatorium hypoleucum, Griseb. (n. sp.): fruticosum; ramulis cylindricis tomentosis; foliis oppositis breviter petiolatis ovatis obtusiusculis repando-serrulatis 3 – 5-plinerviis supra rugosis glabris subtus albo-tomentosis epunctatis ($2\frac{1}{2}$ – $1\frac{1}{2}$ poll. longis); corymbis oligocephalis contractis; capitulis 30 – 40-floris turbinato-hemisphæricis (3 – 4 lin. diam.) ternato-subsessilibus; receptaculo inter squamas involucri brevi apice plano; involucro dense lanato, squamis subtriserialibus imbricatis lanceolatis acuminatis subadpressis, exterioribus brevioribus; achenio scabriusculo; pappi pilis apice paullisper incrassatis. — "Prope villam Nouvelle Sophie dictam, in saxosis, etc. Flores purpurei." (1629.)

Eupatorium cynanchifolium, DC. "In præruptis: flores albi." (1632.)

Eupatorium ageratifolium, DC. "In montanis. Flores albi vel subrosei." (1633.) [Forma angustifolia, 297.]

Eupatorium villosum, Sw. "Juxta Cobre in collibus." (296.)

Critonia Dalea, DC. "In saxosis ad Nouvelle Sophie." (Coll. "Sept. 1859 – Jan. 1860," 1311.)

Critonia imbricata, Griseb. (n. sp.): glabra; foliis lanceolatis acuminatis serrulatis in petiolum brevem basi attenuatis; panicula fastigiata; capitulis breviter pedicellatis trifloris; involucro 6-seriali, squamis obsolete striatis ciliolatis plerisque subæqualibus ovatis obtusatis, intimis ovato-oblongis; achenio hispidulo. Folia 3 – 4 poll. longa, 10 lin. lata, petiolo 2 – 3 lin. longo: involucrum 3 lin. longum. — "Secus ripas rivulorum prope Monte Verde." (Coll. "Jan. – Jul. 1859," 1311.)

Hebeclinium macrophyllum, DC. (298.)

Mikania hastata, Willd. (302.)

Mikania Swartziana, Griseb. Fl. Ind. Occ. *Eupatorium Houstonis*, Sw., non L. (303.)

Mikania trinitaria, DC., var. *M. volubilis*, Poepp. Cub.! (301.)

Mikania gonoclada, DC. (300.)

Mikania corydalifolia, Griseb. (n. sp.): glabra; caule volubili gracili suffruticoso; foliis membranaceis longe petiolatis tripartitis palmatinerviis, segmento medio oblongo-

lanceolato, lateralibus duplo brevioribus sæpe inæqualiter bilobis; corymbis brevibus, pedunculis angulatis basi subalatis; capitulis inæqualiter pedicellatis ternatis umbellatisque; involucro bracteolam lanceolatam parum superante (2 lin. longo), squamis oblongis acutiusculis; corollæ limbo campanulato 5-dentato tubum æquante; achenio glanduloso. — "In monte Nima-nima dicto, etc. Flores albi." (299.)

Erigeron Jamaicensis, Sw. "In saxis humidis." (305.)

Erigeron rivularis, Sw. var. "Inter saxa ad ripas rivulorum." (306, 1312.)

Erigeron bellioides, DC. (304.)

Erigeron Canadensis, L. (1313.)

Baccharis ptarmicifolia, DC. (1314.)

Pluchea odorata, Cass. (308.)

[Pterocaulon virgatum, DC., var. *P. alopecuroides*, DC. (307.)

LANTANOPSIS, C. Wright, mscr. (n. gen. Melampodinearum.) Capitula biflora, vel flore altero abortivo uniflora, dimorpha. Involucrum biseriale, utrumque 3–4-phyllum, interius membranaceum. Receptaculum minutum, nudum. Corolla *alterius* capituli ♂ rotato-quadrifida, antheris 4 connexis facile separandis exsertis ecaudatis nigricantibus stylum simplicem hispidulum includentibus, flore secundo ♀ vel abortivo nudo; *alterius* corolla ♀ bi–trifida, lobis integris vel obscure crenatis, stylo bifido, ramis ejus revolutis teretibus acutis puberulis, flore secundo ♂ nunc in rudimentum stipitiforme reducto. Achenium subglobosum, calvum, superne glanduloso-papillosum et tuberculo papilloso minuto coronatum. — Herba suffruticosa, gracilis, strigoso-hispidulo: folia opposita, rhombeo-lanceolata, supra basin serrulata, triplinervia: capitula glomerata, glomerulis terminalibus supra folia suprema subsessilibus vel breviter pedunculatus subsolitariis vel cymas breves constituentibus.

Lantanopsis hispidula, C. Wright. mscr. Habitu *Unxiæ*, verum structura *Tetrantho* et imprimis *Desmocephalo* fortasse parum distincto accedit. "Secus rivulos prope Monte Verde. Flores albi." (1315.)

Micrococcia repens, Hook. f. Fl. Galap. — Simillima habitu *Tetrantho litorali* Sw. Stylus floris ♂ in nostra bifidus, supra antheras exsertas prominens, — forsan in aliis capitulis integer. (312.)

Ogiera ruderalis, Griseb. *Melampodium ruderale*, Sw. *Kegelia*, Schultz Bip. *Tetranthus*, Griseb. Pl. Carib. (310.)

Acanthospermum humile, DC. (311.)

Wedelia reticulata, DC. "Ad vias." (1634.)

Bidens leucanthus, Willd. (317.)

Bidens leucanthus, Willd., forma discoidea, = *B. pilosa*, L. (316.)

BIDENS COREOPSIDIS, DC. et var. foliis superioribus magis dissectis. *Cosmos luteus*, Bot. Mag. t. 1689. (314.)

[BIDENS BIPINNATUS, L. 315.]

[COSMOS CAUDATUS, Kunth. Specimina pauca coll. 1856–7. 318.]

VERBESINA (HAMULIUM) ALATA, L. (1316.)

ANCISTROPHORA WRIGHTII, A. Gray in Mem. Amer. Acad. Genus ex achenio marginato *Spilanthi* affine. [Melius a Schultz Bip. in Bonplandia 1861 ad *Hamulium* allatum.] " Prope Monte Verde, in calcareis rupibus." (1317.)

SALMEA GRANDICEPS, Cass. *S. scandens* DC. excl. syn. Linn., et *S. Eupatoria* β. DC. (309, 771.)

ISOCARPHA ATRIPLICIFOLIA, R. Br. (Sine numero.)

[SYNEDRELLA NODIFLORA, Gærtn. 320.]

CHRYSANTHELLUM PROCUMBENS, Rich. (319.)

CALYDERMOS? SPILANTHOIDES, Griseb. (n. sp.): caule gracili striato-angulato glabro; foliis petiolatis rigidis elliptico-oblongis mucronatis remote mucronato-denticulatis repandisque triplinerviis supra glabris lucidis subtus ad venas hispidulis; pedunculo terminali folia summa subæquante tricephalo; capitulis hemisphæricis subsessilibus, vel lateralibus pedicellum subæquantibus; involucro sub-biseriato, squamis ovato-deltoideis; paleis superne dilatis acutiusculis; achenio prismatico 4–3-gono calvo apice minutissime denticulato glabro. — Corollæ non extant: receptaculum breviter conicum. Folia *Spilanthes insipidæ* Jacq., quæ pedunculis elongatis et achenio differt. — " In jugo montium, prope St. Jago." (313.)

PECTIS (PECTIDIUM) PUNCTATA, Jacq. (290, 1630.)

POROPHYLLUM RUDERALE, Cass. *P. ellipticum* Cass. (321.)

GNAPHALIUM ALBESCENS, Sw. var. CUBENSE, Griseb.: foliis discoloribus supra glabrescentibus; involucri squamis interioribus cuspidatis. Accedit ad formas Boreali-Americanas (*G. polycephalum* Michx.) involucri squamis obtusioribus distinctis. (322.)

[GNAPHALIUM AMERICANUM, Mill., Sw. 323.]

NEUROLÆNA LOBATA, R. Br. (325, 772.)

[ERECHTHITES HIERACIFOLIA, Raf., var. fere *carduifolius*. Coll. 1856–7, 324.]

[EMILIA SONCHIFOLIA, DC. Coll. 1856–7, 326.]

SENECIO TRINEURUS, Griseb. (n. sp.): *Conogynoxys*, fruticosus, volubilis, glaber; ramulis striato-cylindricis, florentibus brevibus; foliis ovatis vel ellipticis acutis integerrimis triplinerviis in petiolum subæquilongum contractis (1–2 poll. longis); corymbis fastigiatis simpliciusculis; involucri squamis 10–12 oblongis acutiusculis (3 lin. longis), accessoriis linearibus erectis triplo brevioribus; ligulis 8 spathulatis involucri

sesquilongiori; disci floribus 16 – 24. — "Prope Monte Verde: alte scandens." [Folia quandoque hinc vel utrinque basi unidentata vel subhastato-angulata.] (327.)

SENECIO PLUMBEUS, Griseb. (n. sp.): *Conogynoxys*, fruticosus, glaber vel glabrescens; ramulis striato-angulatis; foliis lanceolatis vel lanceolato-oblongis breviter acuminatis basi in petiolum attenuatis superne repandis remoteque denticulatis livido-virentibus (4 – 6 poll. longis), venis tenuibus pinnatis; corymbis pedunculatis simpliciusculis; involucri squamis 8 oblongis (2 lin. longis) obtusiusculis, accessoriis latiusculis basi connexis quadruplo brevioribus; ligulis 8 obovatis involucri $\frac{1}{3}$ longioribus; disci floribus 8 – 16; achenio hirto. — Species foliis rigidiusculis minutissime pellucido-punctatis et venulis libere dichotomis sequenti affinis. — "Prope Monte Verde ad ripas rivulorum. Caulis 10 – 15-pedalis, basi circa poll. 2 diametro." (328.)

SENECIO POLYPHLEBIUS, Griseb. (n. sp.): *Syllepis*,* arborescens, glaber; ramulis angulatis; foliis elongatis lanceolato-oblongis acutis remote denticulatis basi integerrima in petiolum attenuatis (12 – 6 poll. longis), venis primariis numerosis pinnatis; corymbis pedunculatis sæpe divisis; involucri squamis junioribus connexis, lobis 5 ovato-oblongis obtusiusculis tubo campanulato triplo brevioribus, squamis accessoriis paucis minute deltoideis; floribus 5 parum exsertis; achenio glabro. — "Prope Monte Verde, secus ripas rivulorum in sylvis opacis. Caulis 20-pedalis." (329.)

SENECIO VULGARIS, L. "In ruderalibus et cultis." (1318.)

LIABUM BROWNEI, Cass. (289.)

LIABUM WRIGHTII, Griseb. (n. sp.): herbaceum; caule simplici adpresse lanuginoso superne aphyllo; foliis spathulato-lanceolatis obtusiusculis eroso-denticulatis supra sparsim pilosulis virentibus subtus niveo-tomentosis sensim in petiolum attenuatis (12 – 6 lin. latis), imis rosulatis, petiolis elongatis alatis quandoque sinuato-dentatis basi subdistinctis; corymbo oligocephalo simpliciusculo; antheris caudatis; pappo molli stramineo subuniseriali, pilis exterioribus brevibus paucis vel nullis. — "In sylvis densis secus rivulos, prope Monte Verde." (288.)

[LERIA NUTANS, DC. Coll. 1856 – 7. 331.]

LERIA MEDIA, Griseb. (n. sp.): foliis lyratis, segmento terminali ovato-oblongo (1 – 1$\frac{1}{2}$ poll. lato) basi subtruncato, cæteris rotundatis deorsum decrescentibus; involucri squamis linearibus acutis; rostro achenii abbreviato. — Folia *L. nutantis* DC., capitula parva (involucro 4 lin. longo) *L. pumilæ* DC. (332.)

LERIA PUMILA, DC. "Ad Monte Verde." (333.)

TRIXIS FRUTESCENS, P. Browne. (330.)

* *Senecio* sect. SYLLEPIS. Capitulum discoideum; involucri squamis connatis. Corollæ basi sensim dilatatæ. Styli tumor basilaris hemisphæricus; rami apice truncati.

LOBELIACEÆ.

Siphocampylus manettiiflorus, Hook. Bot. Mag. t. 4403. "In præruptis prope Monte Verde." (339.)

Lobelia Cliffortiana, L. (340.)

Tupa assurgens, A. DC. "In agris rudis, secus margines sylvarum, ad Monte Verde." (338.)

Tupa imberbis, Griseb. (n. sp.): foliis elliptico- vel obovato-oblongis acutiusculis basi in petiolum attenuatis sinuato-dentatis, venis subtus piliferis vel glabrescentibus; racemo laxo glabrescente apice cernuo, pedicellis bracteam breviter linearem 4–3-plo superantibus; calycis tubo turbinato-hemisphærico, lobis subulatis corolla (pollicari) tenui apice incurva glabra purpurascente quadruplo brevioribus; staminibus glaberrimis; antheris omnibus barba terminali destitutis. — Folia 5–4 poll. longa [venis subtus grosse reticulatis], superiora decrescentia, ovata, inferiora 2–1½ poll. lata. — "In sylvis opacis prope Monte Verde." (1319.)

Isotoma longiflora, Presl. (337.)

MYRSINEÆ.

Myrsine læta, A. DC. Specimina fructifera. (350.)

Wallenia clusiifolia, Griseb. Fl. Ind. Occ. "Prope Monte Verde, in montanis: arbuscula." (352, [460,] 1332.)

Ardisia bumelioides, Griseb. (n. sp.): glabra; foliis rigidis chartaceis obovatis spathulatisque (4–3 poll. longis) obtusis basi cuneata in petiolum attenuatis integerrimis subimpunctatis, venis costatis subtus prominulis reticulo connexis, venulis extimis liberis; paniculis contractis corymbosis sessilibus terminalibus seu lateralibus; pedicellis drupa brevioribus; calyce 5- (–6-) partito, segmentis ellipticis acutiusculis serrulatis demum reflexis; stylo brevi filiformi; stigmate minuto truncato. — Specimina fructifera, sed affinia videntur *A. Xylosteoidi* Griseb., quæ sectionem *Anardisiam* Griseb. format. Drupa lin. 2 diametro, parce glandulosa: semen basi excavatum, albumine cartilagineo. — "Ad Monte Verde in sylvis opacis. Frutex biorgyalis, drupis immaturis e virido purpureis." (351.)

Ardisia multiflora, Griseb. (n. sp.): *Euardisia*, glabra; foliis coriaceis spathulatis vel obovato-oblongis obtusiusculis basi cuneata subsessilibus integerrimis impunctatis aveniis; panicula terminali effusa pyramidata, pedicellis umbellatim 2–5-natis gracilibus, bracteis minutis deciduis; calyce minuto 5–4-fido, lobis obovatis acutis; corollæ (2 lin. diam.) segmentis ovatis obtusiusculis æstivatione contortis; antheris conicis cuspidatis rima longitudinali dehiscentibus filamento tenui æquilongis; stylo filiformi;

stigmate minuto. — Folia 4 – 2, panicula 6 – 8 pollices longa. — "Prope Monte Verde. Arbor gracilis: flores cum tota panicula alba." (1334.)

ARDISIA JACQUINIOIDES, Griseb. (n. sp.): glabra; foliis coriaceis spathulato-lanceolatis integerrimis margine revolutis basi in petiolum attenuatis minute punctatis subtus venosis; racemis axillaribus et terminalibus paucifloris folio duplo superatis; calyce 5-partito, segmentis ovato-rotundatis ciliolatis a drupa reflexis. — Specimen fructiferum, habitu exacte *Jacquiniam armillarem* referens, sed drupa monosperma, semen basi excavatum, embryone respectu drupæ transverso, albumine cartilagineo. Folia tripollicaria, 6 – 10 lin. lata. Drupæ 3 lin. diametro. (349.)

JACQUINIA RUSCIFOLIA, L., Jacq. Amer. t. 57. (353, et in nonnullis, errore quadam, 349, qui numerus ad præcedentem spectat.)

[No. 1333 est Myrsinea quædam a Grisebachio omissa, specimina imperfecta.]

SAPOTEÆ.

CHRYSOPHYLLUM OLIVIFORME, Lam. (344 [coll. 1859], 1322.)

[CHRYSOPHYLLUM CAINITO, L. 344, coll. 1856 – 7. fl. & fruct.]

CHRYSOPHYLLUM GLABRUM, Jacq. (345, 1328, 1636.)

LUCUMA PAUCIFLORA, A. DC., forma latifolia. (346, 346[a].)

SAPOTA POLITA, Griseb. (n. sp.): *Micropholis;* ramulis pedicellisque rufo-sericeis; foliis elliptico-lanceolatis vel oblongis in acumen angustum obtusum apice protractis nitido-glabris politis margine subrecurvis (2 – 4 poll. longis); pedicellis geminis vel solitariis; calyce 5-partito rufo-sericeo; corolla basi lata ad medium 5-fida, lobis rotundatis (lin. 2 longis); antheris deltoideo-subrotundis appendices incurvas subæquantibus; bacca globosa apiculata polita 4-loculari 4-sperma (16 lin. diam.). — Proxima *S. rugosæ*, Griseb. Fl. Ind. Occ. (*Chrysophyllo*, Sw.), a qua foliis angustioribus et bacca polita differt. Pericarpium tenue: semina pollicaria, subtrigono-convexa, testa dura nitide fusca, hilo pallido longitudinali a placenta soluto: albumen carnosum: radicula infera, cotyledonibus planis crassiusculis, margine altero hilo contiguo. — "In sylvis prope Monte Verde. Arbor excelsa: flores albi: fructu rubro." (1323.)

SIDEROXYLON MASTICHODENDRON, Jacq. *Bumelia pallida*, Sw.! (1324.)

SIDEROXYLON DICTYONEURUM, Griseb. (n. sp.): ramulis glabratis; foliis elliptico-oblongis vel ellipticis (2 – 1-poll. longis) acutis glabris subtus pallidis reticuloque venarum prominulo exsculptis longiuscule petiolatis; pedicellis fasciculatis puberulis petiolo vulgo brevioribus; calyce [4 –] 5-phyllo crassiusculo extus pubescente corolla [4 –] 5-partito parum superato; filamentis brevibus appendices ovatas subintegras æquantibus corollæ segmentis subduplo superatis; antheris ovatis latere dehiscentibus; ovario

biloculari. — Characteribus accedit ad *S. elegans*, A. DC., idemque ad genus certius determinandum seminis cognitione eget. — "In sylvis prope Monte Verde: arbor mediocris." (1329, 1330.)

Dipholis montana, Griseb. *Bumelia montana*, Sw. (1326, 1327, 1637.)

Dipholis salicifolia, A. DC. (1325.)

Bumelia glomerata, Griseb. (n. sp.): ramulis calycibusque rufo-sericeis; foliis spathulatis obovatisque (12 – 6 lin. longis) obtusis basi obtusiusculis rigidis margine subrecurvis glabris breviter petiolatis; floribus glomerato-subsessilibus; corolla quinquefida calyce sesquilongiori, appendicibus exterioribus parvis ovatis acutis, interioribus deltoideis serratis; bacca retuso-subglobosa (4 lin. diam.). — Habitus fere *Vaccinii;* a cæteris Indiæ Occidentalis *Bumeliis* differt floribus subsessilibus, corolla ad medium divisa et bacca (in unica specimine visa) disperma: structura vero seminis ignota est. (347.)

STYRACEÆ.

Symplocos Cubensis, Griseb. (n. sp.): ramulis hirsutis; foliis ($1\frac{1}{2}$ – 1 poll. longis) ovalibus obtusis margine revolutis subintegerrimis vel superne repando-crenulatis supra glabris subtus ad medianum hirsutis; pedunculis unifloris cernuis petiolum subæquantibus; calycis lobis ovato-subrotundis obtusiusculis ciliatis, bracteolis subrotundis ciliatis remotiusculis; petalis 5 obovato-oblongis; staminibus monadelphis; drupa ovoideo-oblonga triloculari (5 lin. longa). — Eandem legit Linden (Cub. no. 1831). — "In sylvis ad Monte Verde. Arbor sat grandis: flores pallide purpurei." (1135, 1321.)

EBENACEÆ.

Diospyros tetrasperma, Sw.; Jacq. Schœnb. t. 312. (348.)

Macreightia Caribæa, A. DC.; Griseb. Fl. Ind. Occ. p. 404, adn. (1331.)

OLEINEÆ.

Forestiera porulosa, Poir. (411.)

Hænianthus salicifolius, Griseb. (n. sp.): foliis rigidis lanceolatis subacutis apice ipso obtusiusculis basi in petiolum 4 – 6-plo breviorem attenuatis, venis inconspicuis; antheris ovoideo-subrotundis pistillum superantibus; drupa ovoideo-subglobosa (lin. 8 longa). — Congener *H. incrassato*, Griseb. Fl. Ind. Occ. (*Chionantho*, Sw.): pedicelli ut in eadem stirpe crassiusculi, in panicula terminali ternati. (409, coll. 1856 – 7.)

Linociera ligustrina, Sw. (409, coll. 1859, et 410, 1387, 1387[a].)

Linociera compacta, R. Br. (408.)

LINOCIERA AXILLIFLORA, Griseb. (n. sp.): *Ceranthus;* foliis rigidis lanceolato-ellipticis acutiusculis glabris; corymbis axillaribus abbreviatis petiolum duplo fere superantibus; pedicellis puberulis ternatis calycem subæquantibus; antheris obtuse deltoideis. — "Monte Verde. Arbor humilis, gracilis, albiflora." (1338.)

APOCYNEÆ.

STRYCHNOS GRAYI, Griseb. (n. sp.): ramulis puberulis spinosis, spinis patentibus oppositis; foliis membranaceis ovato-oblongatis obtusatis (8 – 10 lin. longis) triplinerviis subtus in axilla nervorum penicillato-pilosiusculis; corymbis terminalibus paucifloris; corolla minuta profunde quinquefida, lobis intus barbatis. "Prope Monte Verde in dumetis. Scandens: flores viriduli, baccis rubellis." (1304.) [Et 432, coll. 1856 – 7.]

THEVETIA NERIIFOLIA, Juss. (1380.)

RAUWOLFIA SALICIFOLIA, Griseb. (n. sp.): glabra; foliis quaternis obverse lanceolatis obtusiusculis basi attenuata subsessilibus supra nitidis subtus glaucescentibus, venis inconspicuis; cymis paucifloris, pedunculo folium dimidium subæquante; calyce 5-fido (pedicello duplo) corollæ tubo (5 lin. longo) 4 – 5-plo breviori, lobis obtuse deltoideis margine subglandulosis; corolla ad faucem plica brevi coarctata, lobis tubo duplo brevioribus. — "Ad Monte Verde in sylvis opacis: arbor humilis, albiflora." (1386.)

RAUWOLFIA NITIDA, L. (397, 1383, 1384.)

ANECHITES ASPERUGINIS, Griseb. Fl. Ind. Occ. *Echites,* Sw. (1663.)

PLUMIERIA OBTUSA, L., γ. LÆVIS, Griseb.: foliis apice rotundatis lævigatis, venis secundariis inconspicuis; corollæ tubo lin. 10 lobis 10 – 18 longis. (1382.) δ. PARVIFLORA, Griseb.: foliis apice rotundatis vel obtusiusculis lævigatis, venis inconspicuis; corollæ tubo lin. 2 – 4 lobis 6 – 8 longis. Ic. Lam. Ill. t. 173, f. 2. (1381.)

PLUMIERIA FILIFOLIA, Griseb. (n. sp.): foliis dense approximatis filiformi-linearibus gramineis glabris sessilibus, venis inconspicuis, mediano prominulo planiusculo; cyma pedunculata pauciflora, bracteis brevibus subtruncatis; calycis lobis mucronato-rotundatis; corolla supra basin tubi puberulam staminifera, lobis ovalibus seu obovato-oblongis plerumque tubo longioribus; folliculis oblongo-linearibus paullisper reticulato-venosis; seminibus alæ subæquilongis, ala ad basin hinc producta. — Folia 6 – 4 pollices longa semilineam lata, utrinque attenuata: corollæ tubus 8 – 6, lobi 10 – 8 lin. longi. — "Ad Nouvelle Sophie. Arbor parvula." (396, 1660.)

FORSTERONIA CORYMBOSA, Mey. Florif. et fructif. (398.)

THYRSANTHUS? CORYLIFOLIUS, Griseb. (n. sp.); ramulis glabratis; foliis oppositis late ellipticis (3 – 4 poll. longis) mucronatis supra glaucescentibus subtus venosis et cum petiolo pilosiusculis, venis secundariis transversis subtus prominulis; inflorescentia con-

tracta spiciformi; calyce subsessili, segmentis ovatis acutiusculis pubescentibus intus uniglandulosis; corolla . . . . .; folliculis cylindricis, junioribus dense pubescentibus. — Affinis videtur *T. spicato* (*Forsteroniæ*, Mey.) sed pube differt. "Prope Santa Catalina de Guantanamo, etc.: scandens." (1664.)

ECHITES ROSEA, A. DC. *E. myrtifolia*, Roem. & Schult., non Poir. *Mesechites myrtifolia*, J. Mull. (1662.)

ECHITES UMBELLATA, Jacq., var. LONGIFLORA, Griseb.: foliis ovalibus seu ovatis, arcubus venarum a margine distantibus; floribus subsolitariis; corolla "viridi-lutea," tubo (lin. 20 longo) calycem quatuordecies lobos obovato-oblongos quater superante. (1661.)

ECHITES CALYCOSA, Rich. Cub. Calyce magno foliaceo sub folliculis persistente habituque accedit ad *Lasegueam*, genus vix admittendum: cum descriptione ejus quoque convenit antheris corneis e basi obtuse cordata acuminatis, corollæ tubo intus piloso glandulisque disci partim distinctis. Specimina plura et a cl. Wright et a cl. Rugel missa speciem floris magnitudine, proportione partium et corollæ loborum forma valde variabilem ostendunt: calycis segmenta basi minute squamata lineas 6 – 12, corollæ "albæ" lobi oblongi vel oblique obovati pollices 1 – 2 longi, tubo sesquilongiores vel quadruplo fere ipsum superantes. (1377.)

ECHITES VALENZUELANA, Rich. Cub. *Rhabdadenia Wrightiana*, J. Mull.! Sed propter comam in seminis apice truncato sessilem non est *Rhabdadenia*, sed cum *Echitidis*, J. Mull. charactere consentanea, etsi species caule fruticoso erecto, corolla infundibuliformi, et pedicellis 1 – 2 axillaribus in genere anomala. — "In pinetis prope Monte Verde. Arbor parvula, gracilis." (399.)

ECHITES SUBERECTA, Jacq. (400.)

ECHITES JAMAICENSIS, Griseb. Fl. Ind. Occ. *E. Domingensis*, Sw., non Jacq. (1376.)

ASCLEPIADEÆ.

ASTEPHANUS OVALIFOLIUS, Rich. Cub. (403, 1379.)

ASTEPHANUS CUBENSIS, Kth., var. PAUCIFLORUS, Griseb.: pedicillis geminis vel subsolitariis. — Forma habitu cum icone Kunthiana (Nov. Gen. t. 237) plane conveniens: columna plicis geminatis decurrentibus alternantibus insignis. (404, 1665.)

AMPHISTELMA FILIFORME, Griseb. Fl. Ind. Occ. (405.)

[ASCLEPIAS CURASSAVICA, L. 401.]

ASCLEPIAS NIVEA, L. (402.)

SARCOSTEMMA BROWNEI, Mey. (1666.)

OXYPETALUM RIPARIUM, Kth. Nov. Gen. t. 231. (406.)

GONOLOBUS TIGRINUS, Griseb. (n. sp.): ramis pube reversa petiolisque hispidulis;

foliis e basi cordata vel subcordata oblongo-lanceolatis apice attenuatis glabriusculis vel in nervos subtus parce hispidulis; corymbis paucifloris subsessilibus abbreviatis petiolum æquantibus; calyce hispidulo corolla ter breviori, segmentis ovalibus; corolla venis picta extus parce puberula intus glabra (lin. 5 – 6 diam.) 5-loba, lobis orbicularibus tubo planiusculo parum longioribus; corona subintegra scutelliformi. (1667.)

Fischeria scandens, DC., Deless. Ic. 5. t. 77. (1378.)

Marsdenia clausa, R. Br. *M. affinis*, Rich. Cub. (1374.)

Marsdenia campanulata, Griseb. (n. sp.): fruticosa, scandens; ramulis bifariam puberulis; foliis lanceolatis elliptico-lanceolatis vel spathulato-oblongis breviter acuminatis basi attenuatis glabris nitidis subtus pallidis; cymæ pedunculis petiolum subæquantibus; sepalis orbiculatis ciliatis corollæ tubo duplo brevioribus; corolla campanulata glabra ad faucem dense barbata, lobis subrotundis tubo urceolato plus duplo brevioribus; coronæ squamis carnosis ovatis obtusis infra medium antheræ adnatis; pollinariis ovoideis; stigmate umbonato. — "Ad Monte Verde. Scandens, 6 – 10-pedalis, floribus viridulo-albis." (1375.)

[Gonolobus sp. affinis *G. rostrato* et *Martinicensi*, sed pedunculo communi nullo, sepalis lanceolatis: specimina pauca in coll. 1856 – 7, a Grisebachio haud visa. 407.]

GENTIANEÆ.

Sabbatia gracilis, Salisb., var. Cubensis, Griseb.: foliis lanceolatis; floribus paucis subfastigiatis longe pedicellatis; calycis segmentis spathulato-linearibus acutis post anthesin excrescentibus. (412.)

Gœppertia volubilis, Griseb. in Jour. Linn. Soc. 6, p. 141.* *Coutoubea volubilis*, Mart. "Ad Monte Verde. Corolla tubo flavido, limbo albo." (1372.)

Lisianthus thamnoides, Griseb. Fl. Ind. Occ. (1347.)

Leianthus longifolius, Griseb. β. gracilis, Griseb.: forma corolla pollicari. (413.)

Zonanthus Cubensis, Griseb. in Jour. Linn. Soc. l. c. p. 145. (nov. gen.†) "In montanis prope La Perla, etc. Frutex 10-pedalis." (1346.)

* Gœppertia, Nov. Gen. (non Nees). Calyx 5-partitus, 2-bracteolatus. Corolla infundibuliformis, marcescens, limbo 5-partito. Stamina 5, e tubo corollæ exserta; filamentis brevibus infra faucem insertis; antheris erectis oblongis immutatis. Ovarium uniloculare; stylo deciduo; stigmate indiviso ovoideo, basi in marginem prominulum producto. Capsula bivalvis, septicida; valvulis paullo introflexis. Semina reticulata marginalia, funiculis dentiformibus inserta. Herba volubilis: folia lanceolata, paribus plerisque distantibus; cymæ trifidæ vel trichotomæ, in racemum elongatum dispositæ (aut sec. Mart. racemus simplex, terminalis). Griseb. l. c.

† Zonanthus. Involucrum calycem cingens, foliolis geminis rotundatis in tubum breviorem connatis, tubo cupuliformi apice intus in marginem annularem integrum producto. Calyx campanulatus, ecarinatus, demum

VOYRIA PALLIDA, Garcke! Parum differt a *V. uniflora*, Lam. squamis oppositis et corollæ lobis ovato-oblongis obtusiusculis. (415, 1373.)

[EUSTOMA EXALTATUM, Griseb. Coll. 1856–7, 414.]

SCROPHULARIACEÆ.

BUDDLEIA AMERICANA, L. [Flores ex cl. Wright albi nec flavi.] (1297.)

[SCOPARIA DULCIS, L. Coll. 1856–7, 376, 377.]

CAPRARIA BIFLORA, L. (375.)

STEMODIA DURANTIFOLIA, Sw. (1639.) [Et 375 coll. 1856–7 pro parte.]

[STEMODIA MARITIMA, L., sine numero, et STEMODIA PARVIFLORA, Ait. coll. 1856–7, 374.]

HEMIANTHUS CALLITRICHOIDES, Griseb. (n. sp.): foliis oppositis minutis (1–1½ lin. diam.) subrotundis pedicellum filiformem parum superantibus; corollæ labio superiori obsoleto, inferiore trifido, lobis oblongis obtusis, medio sesquilongiori; filamentis basi dente minuto auctis. — *H. micranthemoides*, Nutt. (ex icone Jour. Acad. Philad. 1, t. 6,) fig. inf. plantam simillimam exhibet, distinctam vero foliis spathulatis, corollæ labio inferiori tripartito, segmento ejus medio "lineari-ligulato" lateralibus multo longiori inflexo, et imprimis dentibus filamentarum filamento ipsi æquilongis. Character generis Nuttallianus omnino quadrat in nostram plantam: inde a *Micranthemo* potius ad Sibthorpieas (inter *Hydranthellam* et *Limosellam*) transponendum erit, a *Micranthemo* calyce 4-dentato unilateraliter fere ad basin fisso, corollæ labio superiori obsoleto, stylo bifido, ejusque ramis filiformibus diversum. — "Secus rivulos in saxis madidis cæspitosum." (378.) [Atque etiam 268 coll. 1859–60, necnon forma vegetior in rivulis ad Cobre, 1640, pro parte. Specimina cum iis *Oldenlandiæ callitrichoidis* male confusa: vide p. 506.]

SCROPHULARIA MICRANTHA, Desv. (non Urv.): *Venitia*, annua, glabra; foliis deltoideo-ovatis grosse duplicato-serratis (poll. 1–2½ longis); thyrso terminali laxo glandulifero, cymis paucifloris; calycis segmentis ovato-lanceolatis acuminatis haud marginatis; corolla calyce sesquilongiori (sesquilineam longa), lobis breviter rotundatis, 4 superioribus æqualibus, inferiori paullo longiori; staminibus exsertis, rudimento quinti nullo.

fissilis, 5-lobus; lobis quadrato-subrotundis planis imbricatis margine membranaceis. Corolla hypocraterimorpha, dextrorsum contorta, ad medium fere 5-loba, tubo campanulato, lobis oblongis obtusis. Stamina medio corollæ tubo inserta; filamentis exsertis; antheris incumbenti-recurvis, loculis connectivo dilatato adnatis. Ovarium placentis suturalibus divisis semi-4-loculare; stylo elongato; stigmate bilamellato. Capsula septicida, bivalvis, carpidiis 2 introflexis semi-4-locularis, placentis polyspermis marginalibus; testa reticulata. Frutex: foliis spathulato-oblongis petiolatis, petiolis in vaginam annularem connexis: pedunculi axillares, solitarii, folia subæquantes, uniflori: corolla virens. Griseb. l. c.

— "Prope Monte Verde nec non in monte Lomo del Gato, secus rivulos: corolla alba." (372, 1345.)

SOLANEÆ.

Schwenkia adscendens, Kunth., Nov. Gen. & Sp. t. 180. (373.)

Brunfelsia purpurea, Griseb. (n. sp.): glabrescens; foliis spathulato-lanceolatis obtusiusculis basi in petiolum brevem attenuatis vel subsessilibus (poll. 2 – 1½ longis); calyce breviter campanulato 5-dentato pedicellis subsolitariis cernuis multo breviori, dentibus rotundatis; corolla purpurea, tubo recto (20 – 22 lin. longo) deorsum attenuato calyce decies limbo ter longiori, lobis rotundatis integris; stigmate breviter exserto. — "In sylvis densis prope Monte Verde. Frutex 4 – 6-pedalis, floribus atropurpureis." (393.)

Brunfelsia vinciflora, Griseb. (n. sp.): glabrescens; foliis elliptico-lanceolatis acutiusculis basi in petiolum brevem attenuatis vel subsessilibus (1½ – 1 poll. longis); calyce breviter campanulato 5-dentato pedicellis subsolitariis multo breviori, dentibus ovato-rotundatis; corollæ tubo incurvo cylindrico (10 lin. longo) calyce quinquies limbo duplo longiori, lobis rotundatis integris; bacca globosa indehiscente (8 – 6 lin. diam.). — "Prope Monte Verde. Frutex 1 – 3-pedalis, floribus purpureis." (394, 1349.) [Huc forte specimina fructifera coll. 1856 – 7, 335.]

Solandra longiflora, Tuss. "Arbores excelsas scandens. Corolla suaveolens, limbo albo, tubo inferne sensim viridescenti lineis 10 rubellis percurso." (1348.)

Datura suaveolens, Humb. & Bonpl. "Secus rivulos: frutex circiter 10-pedalis." (1641.)

Capsicum baccatum, L. (384.)

Solanum nodiflorum, Jacq. (384.)

Solanum triste, Jacq. (388.)

Solanum callicarpifolium, Kunth. (379.)

Solanum virgatum, Lam.; Dun. Sol. t. 4. *S. radiatum*, Sendtn. Ab affini *S. lento* Cav. differt foliis supra glabriusculis, calyce tomentoso et appendicibus ejus 10 brevioribus. Specimina extant præterea e Haiti, Teapa, Panama, Venezuela, Ecuador, et Peruvia. (385.)

Solanum Aquartia, Dun. — Jacq. Amer. Pict. t. 15. (1642.)

Solanum crotonoides, Lam.; Dun. Sol. t. 15. Bacca matura pollicem diametro. (382.)

Solanum Jamaicense, Sw.! (380.)

[Solanum cardiophyllum, Dun. Coll. 1856 – 7, 381.]

[Solanum inclusum, Griseb., vel affine, a Grisebachio casu omissa. 1350.]

Cestrum hirtum, Sw. "Baccæ cæruleæ." (386.)

CESTRUM LAURIFOLIUM, L'Her. (1352, 1352[a].)

CESTRUM DAPHNOIDES, Griseb. (n. sp.): ramulis villoso-pubescentibus; foliis lanceolato-oblongis (2 – 1½ poll. longis) obtusis subcoriaceis subtus puberulis; floribus subsessilibus glomeratis vel solitariis; calycis dentibus minutis; corolla (semipollicari) glabra, tubo filiformi sursum paullo dilatato, lobis ovatis obtusiusculis; staminibus inclusis infra faucem corollæ insertis, filamentis anthera triplo longioribus edentatis glabris; bacca (juniori) oblonga. — Idem in Insula S. Thomas legit Holton. — "Cult. ad Monte Verde: flores flavido-viriduli." (1351.)

[CESTRUM DIURNUM, L. et C. MACROPHYLLUM, Vent.? in coll. 1856 – 7 commixta, 387.]

BIGNONIACEÆ.

CRESCENTIA CUJETE, L. (361[a]) et C. CUCURBITINA, L. (361.)

SCHLEGELIA PARASITICA, Miers. *Tanæcium parasiticum*, Sw. (434.)

JACARANDA SAGRÆANA, DC. *Tanæcium paniculatum*, Sieb. Martin. 87. A simili *J. cærulea*, Griseb. (*J. Bahamensi*, DC., non R. Br.) differt corolla breviori (pollicem longa) puberula, et imprimis capsula elliptico-oblonga basi acutiuscula apice obtuse apiculata duplo angustiori (lin. 8 lata). "In pinetis. Corolla purpurea." (360.)

TECOMA LEUCOXYLON, Mart. (1339.) Var. minus lepidota. (1338.)

TECOMA LEPIDOPHYLLA, Griseb. *Bignonia lepidophylla*, Rich. Cub. t. 59. Affinis Tabebuiis simplicifoliis DC., ad *Tecomam* revocandis. Diagnosi apud A. Richard hæc addentur: folia opposita vel alterna, basi rotundata vel angustata, supra demum virentia squamisque amissis nitida, subtus candido-lepidota: calyx junior clausus, ovoideus, demum breviter bilabiatus, labiis inæqualibus sæpe rotundato-integris: antheræ loculi oblongi, divergenti-pendula: ovarium disco prominulo cinctum, placentis dilatatis medio contiguis biloculare: capsula siliquiformis, teretiuscula, 3 – 5 poll. longa, valvis tricarinatis, dissepimento contrario planiusculo subcarnoso: semina lin. 10 longa, ipsa ovoideo-rotunda, rhaphe impressa, ala utraque rotundata pellucida diametro loculi æquali.* — "In præruptis ad Monte Verde: arbor circiter 50-pedalis, floribus purpureis." (1341.)

* Species Cubensis *T. lepidophyllæ* Griseb. affinis est: —

TECOMA MYRTIFOLIA, Griseb. (n. sp.): fruticosa, tortuosa, glabra; ramis vetustis spinescentibus; foliis simplicibus sparsis vel fasciculatis lepidotis subtus candidis minutis (lin. 3 – 4 longis) spathulato-oblongis brevissime petiolatis rigidis margine revolutis, mediano supra impresso; fasciculis paucifloris; calyce lepidoto inæqualiter 5-dentato corolla quadruplo breviori; corolla glabra inferne tenui duplo stamina superante; antheræ loculis oblongo-linearibus strictis, altero erecto, altero pendulo; capsula lineari-acuminata teretiuscula, valvis carinatis; seminum alis loculum subæquantibus. — Legit Rugel prope Matanzas.

Bignonia unguis, L. (359, 1340.)

Pithecoctenium Aubletii, Splitg. (1337.)

ACANTHACEÆ.

Ruellia geminiflora, Kth., γ. canescens, Griseb. *Dipteracanthus canescens* Nees in DC. (366.)

Ruellia tuberosa, L. *Cryphiacanthus Barbadensis* Nees. (1343.)

Stenandrium scabrosum, Nees. *Ruellia scabrosa* Sw. (1344.)

Pachystachys coccinea, Nees. (362.)

Dianthera obtusifolia, Griseb., var. hirsuta. *Rhytiglossa obtusifolia*, β. Nees in DC. (367.)

Dianthera peploides, Griseb. (n. sp.): caule filiformi repente (1–3-pollicari) glabrescente; foliis ovato-subrotundis petiolatis minutis (2–1½ lin. diam.); floribus 3 (–1) in spica simplici distantibus; calycis segmentis 5 lineari-acuminatis corolla triplo brevioribus; corollæ labiis tubo quadruplo brevioribus; antherarum loculis oblongis contiguis parallelis, altero altiori; capsula elliptica puberula in unguem æquilongum contracta. — Affinis *D. reptanti* (*Rhytiglossæ* Nees). — "Prope Monte Verde, ad saxos secus rivulorum margines. Corolla alba, palato sparsim rubro-guttato." (365.)

[Dianthera reptans, Griseb. Coll. 1856–7, specimina pauca; in nonnullis spica demum elongata multiflora. 364.]

[Dianthera comata, L. 363.]

Anthacanthus spinosus, Nees. (368, 369.)

Anthacanthus bispinosus, Griseb. (n. sp.): glabrescens; spinis setaceis (3–4 lin. longis) utrinque geminis patentibus folia rhombeo-oblonga vel ovato-oblonga paucidentata acuta membranacea sæpe æquantibus; floribus solitariis subsessilibus; calycis segmentis inæqualibus, majori lanceolato capsulam subæquante, binis lineari-setaceis; capsula lanceolata (2 lin. longa) sessili ad basin usque 4-sperma. — Flos ignotus, sed habitus omnino *A. Jamaicensis* Griseb. (*Justiciæ acicularis* Sw.). — "Prope Monte Verde secus ripas rivulorum. Frutex gracilis, 1–2-pedalis, floribus albis." [Corollæ nonnullæ in herb. meo repertæ parvæ (lineas 3–4 longæ), hypocraterimorphæ, labio superiori bipartito tubo quadruplo, inferiori alte tripartito tubo triplo breviori, lobis omnibus rotundatis planis: stamina 4; antheræ longiorum didymæ, loculis parallelis basi abrupte mucronulatis, breviorum loculo altero casso vel abortu nullo. Char. floris fere *Chameranthemi* sed habitu diversus.] (1342.)

Dicliptera assurgens, Juss. (1638.)

GESNERIACEÆ.

Bellonia spinosa, L. (370.)

Rytidophyllum tomentosum, Mart. (356, coll. 1856 – 7 et Jan. – Jul. 1859.)

Rytidophyllum petiolare, DC. A præcedente foliis latioribus petiolatis et corolla coccinea differt. (356, coll. Sept. 1859 – Jan. 1860.)

Duchartrea viridiflora, Decaisne in Ann. Sci. Nat. Ser. 3, 6, t. 8. (354.)

Conradia humilis, Mart. "Corolla lutea." (355.)

Conradia corrugata, Griseb. (n. sp.): suffruticosa, nana, pube hispida; foliis rosulatis valde rugosis lanceolatis subsessilibus crenato-repandis supra muricato-asperis subtus ad costas hispidis; floribus axillaribus breviter pedicellatis coccineis; calycis tubo teretiusculo, lobis ovato-lanceolatis acuminatis trinerviis corolla multo brevioribus; corolla (sesquipollicari) clavata, tubo rectiusculo infra limbum parvum obliquum constricto, lobis minutis rotundatis crenatis. — "Prope Monte Verde: caules e fissuris rupium, nunc brevissime exserentes implexi, nunc pedales nodosi." (1335.)

Collandra sanguinea, Griseb. *Alloplectus sanguineus* Mart. *Besleria* Pers. Tuss. Fl. 1, t. 19. Proxima *C. aureo-nitenti*, Hanst., distincta sepalis corollam subæquantibus. (357.)

Columnea tincta, Griseb. (n. sp.): suffruticosa; pilis articulatis longiusculis; foliis obovato-oblongis (5 – 2 poll. longis) sæpe inæqualibus superne obsolete serrulatis vel repando-integerrimis demum subglabratis, ciliis persistentibus; pedunculis fasciculatis petiolum subæquantibus calyceque hirsutis, hoc rubro-colorato corollam dimidiam æquante, segmentis oblongis acutis remote dentatis; corolla "flava" pilosa fere ad medium bilabiata, lobis lateralibus oblongis obtusis patentibus galeæ obtusæ subintegræ vel emarginatæ ad medium adnatis et æquilongis, lobo inferiori oblongo-lineari tubo clavato supra basin rectiusculo parum breviori. — "Epiphytica supra arborum truncos in sylvis densis." (358, 1336.)

CONVOLVULACEÆ.

[Ipomœa Bona-nox, L. *Calonyction speciosum* Chois. 450.]

Ipomœa tuberosa, L. (1657.)

Ipomœa dissecta, Pursh, non R. Br. *I. sinuata* Orteg. (1656.)

Ipomœa quinquefolia, Griseb. *Batatas quinquefolia* Chois. (441 [lapsu calami in coll. 1859 – 60], 448.)

Ipomœa fastigiata, Sweet. (458, 1648.)

Ipomœa sidifolia, Chois. (453, 1655.)

Ipomœa umbellata, Mey.! Desc. Fl. t. 524. (1649.)

[IPOMŒA PES-CAPRÆ, Sw. Coll. 1856–7. 452.]

IPOMŒA HEPTAPHYLLA, Griseb. (n. sp.): *Pes-Capræ*, glabra, volubilis; foliis 7-partitis, segmentis spathulatis subsessilibus repando-integerrimis; cymis pedunculatis; sepalis ovatis rotundatis corolla triplo brevioribus, 2 exterioribus brevioribus; corolla supra basin ventricosa purpurea (sesquipollicari); capsula ellipsoidea biloculari calycem adpressum adæquante; seminibus oblongatis ventre glabris dorso villosis margineque lana (semipollicem longa) patente instructis. — Affinis *I. macrorrhizæ* R. S., et verosimiliter est *I. macrorrhiza* Chois. (non R. S. et exclus. syn. Burm.). Specimina Wrightiana juvenilia sunt, sed congrua cum Haitiensibus a Mackenzie collectis. (1371.)

IPOMŒA TENUISSIMA, Chois. (1651.)

IPOMŒA ARGENTIFOLIA, Rich. Cub. Similis *I. lachnea* Spreng.! sed valde distincta. "Prope Nouvelle Sophie in collibus umbrosis. Corolla atro-coccinea." (449.)

IPOMŒA RACEMOSA, Poir. *Exogonium* Chois. *Calystegia Berterii* Spreng. in pl. Bertero! (1650.)

[IPOMŒA QUAMOCLIT, L. Coll. 1856–7, 447. Et I. COCCINEA, L., sine numero.]

IPOMŒA PURPUREA, Lam. *Pharbitis hispida* Chois. (451.)

IPOMŒA ACUMINATA, R. S. (non R. P.). *Pharbitis mutabilis* Chois. (1647.)

CONVOLVULUS MICRANTHUS, R. S. (455, 1654.)

CONVOLVULUS HAVANENSIS, Jacq., var. corolla majori. (1653.)

CONVOLVULUS NODIFLORUS, Desc. (1652.)

EVOLVULUS ARBUSCULA, Poir. (456, 1658.)

[EVOLVULUS NUMMULARIUS, L. Coll. 1856–7, 457.]

[DICHONDRA REPENS, Forst. Coll. 1856–7, 459.]

CUSCUTA AMERICANA, L. (1659.)

HYDROLEACEÆ.

NAMA JAMAICENSIS, L. (416.)

BORAGINEÆ.

CORDIA ALBA, R. S. *Varronia calyptrata* DC. (425.)

CORDIA GERASCANTHUS, Jacq. (1644.) [Lapsu calami specimina nonnulla sub no. 1664 distributa.]

CORDIA GERASCANTHOIDES, Kth. (414, 1369.)

CORDIA NITIDA, Vahl, apud West. (1367, fl., 1368, fr.)

CORDIA SULCATA, DC. *C. macrophylla* Vahl! non Mill. (427.)

CORDIA ULMIFOLIA, Juss. (423.)

Cordia microphylla, R. S.: fruticosa, aspera; foliis (4 – 10 lin. longis) spathulatis vel obovato-subrotundis obtusis rugosis supra bullato-muriculatis subtus adpresse setosis; fasciculis plurifloris breviter pedunculatis folia subæquantibus; calyce campanulato breviter 5-fido strigoso corollæ tubum dimidium æquante, lobis subulatis ab initio distinctis; corolla hypocraterimorpha, lobis obovatis tubum cylindricum dimidium æquantibus; staminibus subinclusis, filamentis glabris corollæ tubo superne insertis. — Eadem est in coll. Linden (Cub. 1723). — "Ad Santa Catalina de Guantanamo: frutex humilis." (421.)

Cordia globosa, Kth. "Prope Santa Catalina etc." (422.)

Ehretia tinifolia, L. (1366, 1370.)

Beureria virgata, G. Don: hispidula, glabrescens; foliis obovato-oblongis vel elliptico-oblongis obtusiusculis supra vulgo albo-tuberculatis breviter petiolatis (1 – 2 poll. longis); cymis vulgo paucifloris; corollæ tubo lobos subrotundos ter superante calyce hispidulo duplo longiori; drupa globosa leviter costata. — *Ehretia virgata* Sw.! Specimen Swartzianum in Haiti, aliud a Greene prope Havanam lectum est. (426.)

Beureria divaricata, G. Don: ramulis divaricatis glabrescentibus; foliis parvis (4 – 8 lin. longis) oblongis vel ovali-oblongis subsessilibus convexo-revolutis supra muricato-hispidulis nitidis subtus glabrescentibus; cyma pauciflora; calyce sparsim puberulo drupam globosam dimidiam æquante. — Corolla non exstat: pyrenæ monospermæ eandem ad fluv. Yumury prope Matanzas legit Rugel.* — "In præruptis prope Monte Verde. Frutex 2 – 5-pedalis, ramis plurimis brevibus rigidis, floribus albis, fructibus rubris." (1365.)

* Cæteræ *Beureriæ*, in Flora Indiæ Occidentalis nostra expositæ, ex magnis Antillis hæ sunt: —

B. calophylla, Griseb.: glabra; foliis *B. Domingensis* Griseb.; cymis expansis; corollæ tubo lobis triplo longiori calycem glabrum duplo superante; drupa ex ic. Rich. ovoideo-globosa pruniformi calyce multo longiori. — Syn. *Ehretia* Rich. Cub. t. 61. In Cuba legit Rugel prope Matanzas eamque arborem parvam dicit.

B. cassinifolia, Griseb.: ramulis albo-puberulis glabratis; foliis rigidis spathulatis vel obovatis obtusis (10 – 12 lin. longis) in petiolum brevem attenuatis supra tuberculato-asperis lævibusque utrinque glabris; cymis paucifloris calyceque sericeis; corollæ tubo lobos subrotundos duplo superante calycem æquante. — Syn. *Ehretia* Rich. *E. virgata* DC.! ex specim. Bertero, non Sw. Ab affini *B. Domingensi* differt calyce breviori 2 lin. longo, petiolo brevi 1 – 2 lin. longo, et foliis parvis: an var.? Bertero legit in Haiti, alia specimina forsan Vahliana, loco non adscripto, exstant in herbario cl. Sonder.

B. spinifex, Griseb.: ramis calyceque glabris; foliis coriaceis parvis (6 – 12 lin. longis) spathulatis supra sparsim hispidulo-tuberculatis vel glabratis subtus glaberrimis breviter petiolatis; cymis patentibus paucifloris, pedicellis cernuis; corollæ tubo lobos subrotundos duplo superante calycem paullo superante; drupa globosa 4-costata. — Syn. *Ehretia* R. S. "Frutex vel arbor parva, in rupibus prope Matanzas," Rugel.

Tournefortia hirsutissima, L. (419, 1362.)

Tournefortia cymosa, L. (1645.)

Tournefortia bicolor, Sw., γ. brachycephala, Griseb. Fl. Ind. Occ. (420.)

Tournefortia laurifolia, Vent. (417, 417ᵃ, 418, 1646.)

Tournefortia ferruginea, Lam. (1363.)

Tournefortia incana, Lam. (1364.)

LABIATÆ.

Hyptis capitata, Jacq. (443.)

Hyptis spicata, Poit. (441 [lapsu calami in distributione pro 444.])

Hyptis suaveolens, Poit. (445, 446.)

Hyptis scoparia, Poit. (1608.)

Micromeria obovata, Benth. "In summo jugo montium. Corolla alba, lobis margine rubro-guttatis." (1643.)

Salvia tenella, Sw., var. foliis subtus pubescentibus. Syn. *S. micrantha* Vahl, formas foliis majoribus speciei Swartzianæ sistens. (1361.)

Scutellaria purpurascens, Sw. (461.)

VERBENACEÆ.

[Stachytarpha Jamaicensis, Vahl. Coll. 1856 – 7, specimina pauca, 442.]

Lippia dulcis, Trev. (440.)

Lantana odorata, L. (441.)

Lantana trifolia, L. (1360.)

[Lantana Camara, L.? Coll. 1856 – 7, specimina pauca, 439.]

[Citharexylum villosum, Jacq.? Coll. 1856 – 7, specimina imperfecta, 438.]

Citharexylum lucidum, Cham. & Schlecht.! *S. quadrangulare* Schauer! non Jacq. (435, 436, 1359.)

Citharexylum Berterii, Spreng. (437, 1356.)

Duranta Plumieri, Jacq. (1358.)

Petitia Pœppigii, Schauer! Distincta a *P. Domingensi* Jacq. foliis subtus densius reticulatis hispidulo-tomentosis, paniculis brevioribus petiolum subæquantibus, et drupis globosis. (428, 1353.)

Callicarpa ferruginea, Sw. (430.)

Callicarpa fulva, Rich. Cub. "Frutex 6 – 10-pedalis, foliis rugosissimis, corollis læte purpureis. (1357.)

Ægiphila elata, Sw. (429, var. 1354: hæc forma ludit corollæ lobis 4 – 5 totidemque staminibus.)

VITEX AVICENNIOIDES, Rich. Cub. — Hæc et *V. ilicifolia*, Rich. Cub. t. 64 (arbor a Linden denuo in rupibus ad fluv. Yumury prope Matanzas lecta) a speciebus generis genuinis foliis vere simplicibus petioloque non articulato recedunt, tamen nec flore nec fructu a *Vitice* distinguendæ sunt. (431.)

VITEX UMBROSA, Sw. (1355.)

CONIFERÆ.

PINUS CUBENSIS, Griseb. (n. sp.): foliis ternis geminisque tenuibus (sexpollicaribus); strobilis solitariis vel geminis pedunculatis ovatis obtusis demum recurvis, apophysi depressa leviter convexa et transversim carinata pallida medio umbonata, umbone parvo breviter mucronato. — "In altioribus Cubæ Orientalis frequens." (598, 1462.)

PODOCARPUS PURDIEANUS, Hook. Ic. Pl. t. 624; forma parvifolia. (1461.)

CYCADEÆ.

ZAMIA INTEGRIFOLIA, Ait. — Jacq. Ic. Rar. t. 635. (1463.)

ZAMIA ANGUSTIFOLIA, Jacq. Ic. Rar. t. 636. *Z. angustissima*, Miq. ex ic. Cycad. t. 1, f. 13. (597.)

NAJADEÆ.

POTAMOGETON NATANS, L. Forma foliis basi acutiusculis, *P. lonchiti*, Tuckerm. specimini Texensi conformis. (604.) [Idem est 603.]

[NAJAS FLEXILIS, Rostk. Coll. 1856 – 7 tantum, 605.]

[TYPHACEÆ. — TYPHA ANGUSTIFOLIA, L. Coll. 1856 – 7, 600.]

AROIDEÆ.

ANTHURIUM CRASSINERVIUM, Schott. (*Pothos* Jacq. Ic. Rar. t. 609.) Costa folii subtus striato-obtusata. (601.)

PHILODENDRON LACERUM, Schott. (602.)

ARISÆMA ATRORUBENS, Blume. Specimen incompletum. (1469.)

PALMÆ.

EUTERPE MANAËLE, Griseb. & Wendl. (*Oreodoxa Manaële*, Mart.?) E. pinnis lanceolato-acuminatis basi latiusculis glabris, mediano supra carinato; spadicis ramis glabris fuscescentibus; floribus remotiusculis (♂ ignotis); bacca nigra opaca (semipoll. diam.). — Pinnæ 32 – 34 pollices longæ, $2\frac{1}{2}$ poll. latæ, basi ipsa reduplicata rhacheos faciei (6 lin. latæ) adnatæ; rami spadicis sesquipedales. "Caudex circiter 50-pedalis, gracilis; frondibus 10 – 15 pedes longis; panicula simplici 2 – 3-pedali; baccis atropurpureis, pulpa tenui. Prope Monte Verde." (1468.)

OREODOXA OLERACEA, Mart. (1467.)

GEONOMA (CALYPTRONOMA) SWARTZII, Griseb. & Wendl. in Griseb. Fl. Ind. Occ. *Elais occidentalis* Sw. (1466.)

BACTRIS PLUMIERIANA, Mart. (1465, 599.)

COMMELYNACEÆ.

CAMPELIA ZANONIA, Rich. (697, 1527.)

TRADESCANTIA PANICULATA, Jacq., var. EFFUSA, Mart. (1714.)

CALLISIA UMBELLULATA, Lam. (695.)

COMMELYNA CAYENNENSIS, Rich. (698.) [678 in schedis nonnullis.]

COMMELYNA PERSICARIFOLIA, DC. (696.)

GRAMINEÆ.

ARTHROSTYLIDIUM FIMBRIATUM, Griseb. (n. sp.): ramorum internodiis gracilibus lævibus; foliis brevibus patentibus lineari-acuminatis basi contractis glabris margine scabris, fimbriis oris vaginæ elongatis patentibus inæqualibus pallidis, longissimis (10 lin. longis) folio fere duplo brevioribus, vagina læviuscula; racemis contractis terminalibus; spiculis 3–5-floris internodium axeos superantibus linearibus brevissime pedicellatis; floribus lineari-acuminatis nervatis internodio rhacheos duplo brevioribus; glumis sterilibus abruptim brevioribus. — "In sylvis densis prope Monte Verde. Culmi 1–3-pedales." (1554.)

ARTHROSTYLIDIUM CAPILLIFOLIUM, Griseb. (n. sp.): internodiis caulis gracilibus (vix lineam diam.) ramulos foliatos dense fasciculatos vulgo excedentibus lævibus; foliis flexilibus tenuissimis capillaceis (3–6 poll. longis) canaliculatis glabris margine scabriusculis, fimbriis oris vaginæ albidis flaccidis (1–2 lin. longis), vagina brevi lævi; racemis depauperatis ramulos terminantibus; spiculis 1–4, lateralibus valde distantibus breviter pedicellatis lanceolatis; floribus fertilibus 2–5 superne nervatis internodio rhacheos clavato triplo longioribus lineari-attenuatis apice obtusiusculis, superioribus caducis; glumis sterilibus deorsum decrescentibus. — "In sylvis densis, frutices vel arbores scandens." (738.)

ARUNDO SACCHAROIDES, Griseb. *Gynerium saccharoides* Humb. (1560.)

ERAGROSTIS CILIARIS, Link. (1550.)

[ERAGROSTIS PILOSA, Beauv. 745.]

SPOROBOLUS INDICUS, R. Br. (1537.)

ARISTIDA STRICTA, Michx., var. COGNATA, Trin. (736, 737.)

LEERSIA MONANDRA, Sw.! (731.)

OLYRA LATIFOLIA, L., var. ARUNDINACEA, Trin. (746.)

OLYRA PAUCIFLORA, Sw. (732.)

OLYRA PINETI, C. Wright. mscr. (n. sp.): culmis aggregatis teneris inferne subaphyllis, nodis constrictis; foliis lanceolatis acutiusculis (6 – 10 lin. longis) lævibus margine scabriusculis, petiolo intus hispidulo, ligula truncata; inflorescentia axillari; racemis supremis ♂, inferioribus in spiculam ♀ solitariam reductis; spiculis glabris; glumis ♂ lanceolato-acuminatis, ♀ subulatis; flore ♀ semiorbiculari lævigato albo apice in apiculum brevissimum obtusiusculum producto. — Affinis *O. paucifloræ*, differt tenuitate et apiculo floris magis distincto. — "Prope Monte Verde, inter pinorum folia dejecta." (1536.)

PHARUS LATIFOLIUS, L. *P. scaber* Kth. (733.)

PHARUS GLABER, Kth. (733 bis, coll. 1859.)

BOUTELOUA HUMBOLDTIANA, Griseb. *Eutriana juncifolia* Kth. exclusis plerisque synonymis. Parum recedit ab icone Kunthii (Nov. Gen. t. 54) flore superiori ♂ vel neutro, tertio in stipitem reducto: valde differt a *B. litigiosa* Lag. (*Aristida Americana* Sw.) floribus basi glabriusculis, secundo magis explicato 5-dentato, dentibus exterioribus et medio aristatis, deinde spicis plerumque unilateralibus earumque spiculis paucioribus magis approximatis, internodio axeos glumis superato. (734, 739.)

TRICUSPIS (TRIPLASIS) SIMPLEX, Griseb. (n. sp.): culmis cæspitosis (4 – 8 poll. longis) nudiusculis; foliis convoluto-filiformibus brevibus flexuosis sparsim et ad apicem vaginæ densius piligeris; racemo spiciformi simplici elongato; spiculis distantibus brevissime pedicellatis; floribus fertilibus 4 – 6 distantibus supra barbulam calli glabris, imo glumam sterilem inferiorem duplo excedente; arista e lobulis eroso-obtusiusculis exserta flore ipso 3 – 4-plo breviori. — Genus ex gluma ima (in hac specie) axin respiciente et ex embryone majusculo (apud Kunth. Rev. t. 67) potius ad Chlorideas transponendum, nec a *Leptochloa* nisi spiculis alternis (non in facie axeos interiori biseriatis) distinctum, eademque charactere ad *Gymnopogon* et *Heterostegam* accedens. — "In rupidus aridis." (1551.)

CHLORIS CRUCIATA, Sw. (1548, 1549.)

[CHLORIS CILIATA, Sw., 743, et C. quædam, 742, coll. 1856 – 7.]

[ELEUSINE INDICA, Gærtn. 744.]

[LEPTOCHLOA MUCRONATA, Kunth., 740, et L. VIRGATA, Beauv., 741, coll. 1856 – 7.]

PASPALUM CONJUGATUM, Berg. (767.)

PASPALUM DISTICHUM, L. var. VAGINATUM, Sw.! (1546.)

PASPALUM PANICULATUM, L. (766.)

[PASPALI sp. 2, coll. 1856 – 7, a Grisebachio non visa, 768, 769; etiam DIGITARIÆ, 763, 765.]

Digitaria filiformis, Mühl. *Panicum*, L. (1544.)

Digitaria setigera, Roth. (764.)

Eriochloa punctata, Ham. (1542.)

Panicum fuscum, Sw. (754.)

Panicum molle, Sw. (1545.)

Panicum diffusum, Sw.

Panicum durum, Griseb. (n. sp.): *Virgaria ;* culmo stricto (sesqui–bipedali) folia subæquante glabrescente, nodis puberulis; foliis lineari-acuminatis rigidis glabris vel basi remote ciliatis; panicula patente subfastigiata (poll. 4 longa), ramis simplicibus sparsis; spiculis (lin. 2 longis) breviter pedicellatis remotiusculis vel geminatis subsecundis erectis elliptico-oblongis acutis pubescentibus testaceo-purpurascentibus; gluma ima ovata 5–7-nervi spiculam dimidiam subæquante, superiori 7-nervi floreque neutro 5-nervi paleato fertilem æquantibus; flore fertili elliptico-oblongo acuto lævi a dorso compresso. — Affine ex icone Triniana *P. velutinoso*, Nees, cui folia brevia et flos transversim rugosus; comparatur *P. Portoricense*, Ham., nobis ignotum. (1539.)

Panicum laxum, Sw.! *P. tenuiculmum* Meyer. (759.)

Panicum pallens, Sw. (750.)

Panicum divaricatum, L. (747.) Var. puberulum, Griseb. Fl. Ind. Occ. *P. glutinosum*, Lam., non Sw. (748.)

Panicum glutinosum, Sw. (757.)

Panícum brevifolium, L. (1538.)

[Panici sp. indeterminata sunt 749, 752, 753, 756 (coll. 1856–7), 758, 761, 762.]

Orthopogon loliaceus, Spreng. (751.)

Orthopogon setarius, Spreng. (1543.)

Isachne leersioides, Griseb. (n. sp.): gracilis, adscendens ($1\frac{1}{2}$–2-ped.), inferne geniculata, pauciramosa; foliis lineari-acuminatis glabris ciliatis (poll. 3–6 longis), vagina pilosa; panicula patente, ramis sparsis distantibus, inferioribus compositis, pedicellis filiformibus spicula summa longioribus; spiculis subglobosis; glumis 2 subæquilongi spicula paullo brevioribus pilosis, inferiori elliptico-lanceolata trinervi, superiori quinquenervi; flore utroque pilosiusculo semigloboso pallente, inferiori ♂, superiori ♀. (755.)

Gymnothrix Domingensis, Spreng. *Pennisetum* Spreng. (1547.)

Echinolæna, sp. Specimen incompletum: accedit ad *E. polystachyam*, Kth., differt foliis petiolatis glumisque glabris. Flore minus indurato coriaceo a Panico recedit. (760.)

Tricholæna insularis, Griseb. Pl. Carib. p. 117. *Trichachne* Nees. *Milium villosum* Sw. *Panicum leucophlæum* Kth. (1541.)

Arundinella Cubensis, Griseb. (n. sp.): gracilis, tripedalis; foliis anguste lineari-

bus, vagina ciliata; panicula longa, ramis inferioribus verticillatis elongatis simpliciusculis; spiculis lanceolatis pallide virentibus; glumis inæqualibus trinerviis florem sterilem superantibus, secunda fertilem ter excedente; arista geniculata flore (vix lineam longo) quinquies longiori. (1552.)

Manisuris granularis, Sw. (1553.)

Andropogon (Heteropogon) secundus, Willd. (1559.)

Andropogon (Gymnandropogon) saccharoides, Sw. (1556.)

Andropogon (Schizachyrium) brevifolius, Sw. (1558.)

Andropogon (Schizachyrium) gracilis, Spreng. (1557.)

Anatherum bicorne, Beauv. *Andropogon*, L. (770.)

Anatherum macrurum, Griseb. *Andropogon*, Michx. (1555.)

TRISCENIA, nov. gen. Spiculæ lanceolatæ, acuminatæ, muticæ, pedicellatæ. Glumæ, inferior membranacea, superior duplo major, cum flore neutro univalvi herbacea eique subæqualis. Flos fertilis solitarius, membranaceus, non induratus, inclusus: palea inferior superiorem binerviam subæquans. Lodiculæ minutæ. Stamina 3, antheræ loculis subdistinctis. Stigmata supra medium florem emersa. Caryopsis libera, oblonga; embryone minuto. — Gramen cæspitosum, habitu *Festuceæ ovinæ;* foliis setaceis recurvis subcompressis supra canaliculatis lævibus culmum subaphyllum (8 – 18 poll. longum) sæpe æquantibus, vaginis latiusculis patulis brevibus membranaceis, margine ligulari ciliato; spiculis racemosis raris racemisque ramos breves distantes paniculæ erectæ angustæ continuæ constituentibus, pedicellis inæqualibus. — Genus a *Panico* flore membranaceo sterilibus glumis (secunda et tertia) tenuiori, embryone minuto, habitu distinctum, potius Andropogineis inserendum, et *Zoysiæ* aliquid affine, si in hoc genere glumam primam *Trisceniæ* suppressam floremque ad paleam solitariam reductum, quandoque etiam nudum, consideramus: sed caryopsis, quæ *Trisceniæ* inter Andropogineas Paniceasve anomala fit embryone minuto, in *Zoysia* et *Leptothrice* adhuc ignota est.

Triscenia ovina, Griseb. — Paniculæ rami inferiores 6 – 8 lin., spiculæ sesquilineam longæ: gluma ima uninervis, nervo virente, secunda cum tertia (flore neutro) virentes, trinerviæ, flore fertili sesquilongiores. (756, coll. ann. 1859.)

[Gramen indeterminatum, a Grisebachio haud visum, coll. 1856 – 7, 735.]

CYPERACEÆ.

Cyperus acuminatus, Torr. (700.)

Cyperus ochraceus, Vahl. (707.)

Cyperus (Diclidium) filiformis, Sw. (702.)

Cyperus (Diclidium) flexuosus, Vahl. *C. stellatus*, Rudge, Guian. t. 20. (704.)

Cyperus (Diclidium) Vahlii, Steud. *C. ferox*, Vahl, non *C. ferax*, Rich. (705.)

Cyperus (Papyrus) giganteus, Vahl. *C. Surinamensis*, Kegel, coll. 37. — Folia ab auctoribus negata, a Kunthio descripta, in nostro specimine cæspitem juxta caulem basi vaginatum formant: culmus 4-pedalis, inferne canaliculato-subteres, apice solo triqueter: spiculæ dense spicatæ, demum subreflexo-patentes, nitide lutescentes. (1529.)

Cyperus (Mariscus) flavomariscus, Griseb. Fl. *Mariscus flavus*, Vahl. (730.)

[Cyperus compressus, L., 1528, necnon Cyperi 701, 703, et 706 haud nominati.]

Kyllingia brevifolia, Rottb. (699.) [Coll. 1859, specimina coll. 1856–7 foliis involucri elongatis diversa.]

Abilgaardia monostachya, Vahl. (1531 bis [an vera ? 708].)

Scirpus (Eleocharis) ochreatus, Griseb. *Eleogenus ochreatus*, Nees. (711.)

Scirpus (Eleocharis) capitatus, L. (712.)

Scirpus (Eleocharis) constrictus, Griseb. *Limnochloa constricta*, Nees. (709.)

Scirpus (Eleocharis) plantagineus, L. *Limnochloa*, Nees. *Eleocharis interstincta*, R. Br. (710.)

[Scirpus lacustris, L. 713.]

Scirpus (Fimbristylis) autumnalis, L., forma elatior. (715.)

Scirpus (Fimbristylis) brizoides, Sm. *Fimbristylis laxa*, Vahl. (714.)

[Scirpus (Fimbristylis) spadiceus, L. 715 bis, lapsus pro 716.]

Scirpus (Oncostylis) juncoides, Willd. *Isolepsis junciformis*, Kth. (1533.)

Cladium occidentale, Schrad. (1534.)

Machærina restioides, Vahl, var. effusa: pedunculis longioribus arcuatis; spiculis pallidioribus; floribus paucioribus. (1535.)

Rhynchospora pruinosa, Griseb. (n. sp.): *Eurhynchospora*, glauca; caule gracili obtuse trigono; foliis planis lineari-acuminatis margine scabris, pagina superiori punctis albidis exasperata; spiculis pallidis elliptico-lanceolatis glomeratis, glomerulis breviter spicatis, spicis parvis oblongis, axillaribus subsessilibus, terminali bracteata; glumis ovatis acutiusculis; stylo bifido; achenio flavente elliptico leviter transversim striato setas 6 sursum scabras æquante rostrum virens conico-acuminatum duplo superante. (1532.) No. 729, specimen dubium, forsan ejusdem speciei monstrositas [sine dubio, speciminibus meis docentibus], spiculis elongatis sterilibus locum glomeruli tenentibus ?

Rhynchospora (Nemochloa) polyphylla, Vahl. (727.)

Rhynchospora (Dichromena) exaltata, Kth., forma oligocephala. *Echinoschœnus sparganioides*, Nees in Mart. Fl. Bras. 3, t. 10. *E. Beyrichii*, Nees. (Formam polycephalam in Venezuela legit Fendler, 2195.) "In sylvis densis, late cæspitosa." (719.)

RHYNCHOSPORA (DICHROMENA) CUBENSIS, Griseb. Fl. Ind. Occ. *Dichromena Cubensis* Pœpp. ex descr. Affinis *Haloschœno capillari* Nees! (*Dichromenæ gracili* Kth.). "In pinetis, dense cæspitosa." (1531.)

RHYNCHOSPORA (DICHROMENA) STELLATA, Griseb. *Schœnus stellatus*, Lam. *Dichromena leucocephala*, Michx. (1530.) [718, coll. 1856–7.]

RHYNCHOSPORA (DICHROMENA) PERSOONIANA, Griseb. *D. Persooniana*, Nees. (717.)

SCLERIA PRATENSIS, Lindl. (723.)

SCLERIA MICROCARPA, Nees. (724, etiam sub 723 [coll. 1856–7, specim. latifol.] cum præcedente.)

SCLERIA SCINDENS, Nees. (726.)

SCLERIA BRACTEATA, Cav. *Macrolomia bracteata*, Nees. (725.)

SCLERIA (HYPOPORUM) FILIFORMIS, Sw. (721, 722.)

[SCLERIA ——— coll. 1856–7 non determinata. 720.]

CAREX SCABRELLÆ, Wahlenb. affinis: an forma ejus foliis latioribus spiculis paucis? (728.)

DIOSCOREACEÆ.

DIOSCOREA LUTEA, Meyer! *D. heptaneura*, Vell. (1711.)

[DIOSCOREA sp. coll. 1856–7 tantum, 692.]

RAJANIA ANGUSTIFOLIA, Sw.! (1713.)

RAJANIA MUCRONATA, Willd. Proxima *R. ovatæ*, Sw.! distincta samara breviori (8 lin. longa) semielliptico-oblonga foliisque brevius petiolatis. *R. cordatæ* L. samara est duplo minor (4 lin. longa). (691.)

RAJANIA HASTATA, L., var. foliis hastato-deltoideis 5–7-nerviis. (1712.)

SMILACEÆ.

SMILAX HAVANENSIS, Jacq.? var. IMPRESSA, Griseb., costis foliorum supra impressis. *S. Coriacea*, Spreng.? (693.)

[SMILAX OBLONGATA, Sw.? Specimina incompleta, fructifera, coll. 1856–7. 694.]

SMILAX DOMINGENSIS, Willd. *S. Schlechtendalii*, Kth. (1526.)

AMARYLLIDEÆ.

BOMAREA EDULIS, Herb. Forma foliis paullo brevioribus quam in icone apud Tuss. Fl. Ant. 1, t. 14. (690.)

HYPOXIS DECUMBENS, L. (1515.)

Bromeliaceæ cæteræque paucæ adhuc indeterminatæ.

XIX.

A Catalogue of Standard Polar and Clock Stars, for the Reduction of Observations in Right Ascension; with a Discussion of their Positions.

By TRUMAN HENRY SAFFORD.

(*Communicated September* 9, 1862.)

The object of the present Catalogue* is to furnish (additional to the very accurate positions of the Berlin Jahrbuch) the means of reducing observations of right ascension with greater convenience and accuracy, and in a somewhat more systematic manner, than by the aid of former catalogues. It is divided primarily into two catalogues, the one of "polar stars," the other of "clock-stars," so called; with a supplementary list of stars which for large instruments are not commonly used in either capacity, but merely as tests of the accuracy of observation and reduction.

Excepting 25 "polar stars," all the stars here given are found either in the Nautical Almanac Catalogue, or in that of the Berlin Jahrbuch.

This Catalogue contains, then, in the first place, the 47 stars of whose apparent places an ephemeris is given in the Jahrbuch; 2 of these being "polar stars," 36 "clock-stars," and 9 of the supplementary list.

In the second place, our Catalogue contains the 25 "polar stars" — stars within 10° of the north pole — mentioned above.

In the third place, all the stars of the Nautical Almanac Catalogue are here given, except α Columbæ and δ Sculptoris, ζ Ursæ Minoris, η Draconis, and γ Cephei, and also the stars below 45° of south declination.

The mean positions in this Catalogue of the 47 stars are derived from Wolfers's

* The Catalogue was originally computed for the use of the Observatory of Harvard College, and has been applied since May, 1862, in the reduction of transits. It is published here with the approval of the Director.

Tabulae Reductionum,* without further investigation. It will be often convenient to have them in the form here presented, which differs from that adopted in those tables. The secular variations given for these stars are the same which Wolfers used, and which are taken from the *Tabulae Regiomontanae*.

Computation of the Mean Places of 25 Polar Stars.

In this discussion the following catalogues have been employed; to the name of each catalogue has been prefixed the abridgment by which it is cited in the course of the work:—

Br. The Fundamenta Astronomiae (full title given in this volume of the Memoirs of the Academy, Pt. I. p. 299).

Gr. Groombridge (full title, *loco modo citato*).

Str. 1815. F. G. W. Struve, Observationes Astronomicae institutae in Specula Universitatis caesareae Dorpatensis. Vol. I. Pars II. Dorpati. 1817. 4to.

Str. 1824. Stellarum Fixarum imprimis duplicium et multiplicium Positiones Mediae pro Epocha 1830.0 deductae ex observationibus meridianis annis 1822 ad 1843 in Specula Dorpatensi institutis; auctore F. G. W. Struve. Petropoli ex typographia academica, 1852. Fol. The positions which I have used are a few for 1824.0 from the Introduction, page xxxviii. *et seqq.*

Schw. Schwerd's Beobachtungen von Circumpolarsternen in mittleren Positionen 1828.0. Von Wilhelm Oeltzen. Aus dem X. B^{de} der Denkschriften der Mathem.-Naturw. Classe der K. Akademie der Wissenschaften. . . . . Wien, 1856. 4to.

Arg. DLX Stellarum Fixarum Positiones Mediae ineunte Anno 1830. . . . [auctore] Argeland[ro]. . . . Helsingforsiae, 1835. 4to.

Pond. A Catalogue of 1112 Stars reduced from Observations made at the Royal Observatory at Greenwich from the Years 1816 to 1833. London. . . . . 1833. Fol.

Hend. Astronomical Observations made at the Royal Observatory, Edinburgh, by Thomas Henderson. . . . . . Vol. III. [to V.] for the Year[s] 1837 [to 1839]. Edinburgh. 1840 [–1843]. 4to.

[The same] reduced and edited by his successor, Charles Piazzi Smyth. Vol. VI. [–IX.] for the Year[s] 1840 [–1845]. 4to.

* Tabulae Reductionum Observationum Astronomicarum ab anno 1860, usque ad 1880. Auctore J. Ph. Wolfers. Additur, Tabulae Regiomontanae ab anno 1850, usque ad 1860, ab Ill. Zech continuatae. Berolini, 1858.

Rob. Places of 5345 Stars observed from 1828 to 1854 at the Armagh Observatory, by Rev. T. R. Robinson, D. D. . . . . . Dublin, 1859. 8vo.

Airy. Airy's "Twelve-Year Catalogue," "Six-Year Catalogue," "Greenwich Observations" from 1854–1858. (For full titles see my paper previously cited, in the present volume, pp. 300, 301.)

The "Greenwich Observations" for 1859 and 1860 have come to hand since the main part of these calculations were made.

Joh. The Radcliffe Catalogue of 6317 Stars chiefly Circumpolar reduced to the Epoch 1845.0, formed from the Observations made at the Radcliffe Observatory under the Superintendence of Manuel John Johnson, M. A., late Radcliffe Observer. With Introduction by the Rev. Robert Main, M. A., Radcliffe Observer. Oxford. 1860. 8vo.

Car. A Catalogue of 3735 Circumpolar Stars observed at Redhill in the years 1854, 1855, and 1856, and reduced to Mean Positions for 1855.0, by Richard Christopher Carrington. London. 1857. Fol.

LeV. Annales de l'Observatoire Impérial de Paris publiées par U. J. Le Verrier, Directeur de l'Observatoire. Observations. Tome XII. [XIII.] Paris. 1860, [1861]. 4to.

Tomes XIV., XV. were received later.

I found, when too late to use them, that Airy's Cambridge Observations contained two or three places which should have been inserted.

No use was made of the *Histoire Céleste*, or Fedorenko's Catalogue; nor of Piazzi, nor Groombridge's right-ascensions. Any material from these sources is of uncertain accuracy; or would require insecure systematic corrections.

The method by which mean places for 1855, and proper motions referred to the ecliptic of the same year have been found, is as follows: The positions of the Fundamenta, where such existed, were reduced from 1755 to 1855 by the use of Struve and Peters's data. In some cases where there was no observed declination for 1755, a value for 1755 referred to the ecliptic of 1855 was assumed, and by a slight modification of the method given in the introduction (p. ix.) to the *Tabulae Regiomontanae* (see, also, Wolfers's *Tabulae Reductionum*, pp. lii., liii. of the Introduction) was made to serve the same purpose. For if (see the place just cited) δ' be supposed known, we shall have ([32]) $x = \frac{\delta' - (d' + d)}{\beta + \alpha}$. In this case the declination for 1755 corresponding to that assumed for the ecliptic of 1855, will be $\delta = d' - d + (\beta - \alpha)\, x$.

The indirect form of Bohnenberger's method which Bessel has given, and which

has been transferred by Wolfers, is greatly preferable to the more direct one. It needs a little more care, however, in the computation.

We have now positions for 1755, referred to the ecliptic of 1855, which agree with *all* the data of the Fundamenta referring to these stars. We have also some modern observations referred with more or less accuracy to the ecliptic of the same epoch, or which we can easily refer to that ecliptic approximately. These give us the means of obtaining a formula which shall be of the form

$$\alpha = \alpha^\circ + h^\circ\,(t - 1755)\,, \qquad \delta = \delta^\circ + i^\circ\,(t - 1755)\,.$$

Where α° δ° are (Bessel's) Bradley's positions of 1755, in cases where they are complete, referred to the co-ordinate-planes of 1855; or, in case the Fundamenta position of 1755 is incomplete, α° is the AR. for 1755 referred to the ecliptic and equator of 1855, by means of δ°, as explained above; δ° being here arbitrary within certain small limits: where again h° i° are *assumed* proper motions referred to the ecliptic and equator of 1855, but *so* assumed as to nearly represent more modern observations. For stars not in the Fundamenta, α° δ° are both arbitrary.

In other words, if all observed positions are referred to 1855 by precession alone, the formulæ

$$\alpha = \alpha^\circ + \text{etc.,} \qquad \delta = \delta^\circ + \text{etc.,}$$

would represent those taken from the Fundamenta *exactly*, and all others *nearly*. But as certain positions are exceptionally incomplete, and others so as a rule, we shall not attempt so to refer them, but shall proceed in the opposite way. We shall compute theoretical places of each star for the epochs of the catalogues. This will be done most conveniently by computing places for epochs at equal intervals, which can then be tested, and afterwards interpolated; thus saving labor, and securing accuracy.

Table I. contains the assumed values of α° δ° h° i°. For the stars contained in Bradley, the values of α° and δ° have been verified by Mr. A. Hall, now Aide at the U. S. Naval Observatory, Washington; who has recomputed the positions referred to the ecliptic of 1755 from them.

From these values positions for 1810, 1830, 1850, 1870 were computed, and in some cases for 1820, 1840, 1860; using Struve and Peters's constants. The positions for 1815 were computed independently, and also interpolated as a check. The proper motions (h' i'), and secular variation (in AR.) were computed for 1830 and 1850; the former by formulæ which will afterwards be cited with some modifications from Bessel, and the latter by the formula,

$$0''.0284 + 0''.1950\,[\mathrm{tg}\,\delta'^2 + \tfrac{1}{2}]\,\sin 2\,\alpha' + 0''.4481\,\sin(\alpha' + 91^\circ\,6')\,\mathrm{tg}\,\delta' + 0.01944\,[h'\,\mathrm{tg}\,\delta'\cos\alpha' + i'\sec\delta'^2\sin\alpha'].$$

The secular variation in declination is

$$-0''.1950 \operatorname{tg} \delta' \sin \alpha'^2 + 0''.4481 \cos (\alpha' + 91^\circ \ 6') - 0''.01944 \ h' \sin \alpha'.$$

This, however, it was not necessary to compute, as existing catalogues furnished by interpolation sufficiently accurate values for our immediate purpose, which was to test the computed right-ascensions and declinations.

Table II. contains the comparison of the theoretical and observed positions; the observed positions having been corrected so as to correspond to the same proper motions as had been previously computed.

In certain cases it was necessary to form the "observed" positions by combining the results of several years' observations. For Henderson's and Le Verrier's AR. this was done by means of the annual variations derived from our computed places: for the Greenwich observations, by the annual variations given in the separate volumes. In either case care was taken to have the "mean epoch" adopted correspond very precisely to the mean of the times of observation.

The computed right-ascension and declination of a star for any time depend strictly each upon four elements (besides precession); upon the AR. and proper motion in AR. for some fixed epoch, and also the Decl. and P. M. in Decl. for the same epoch.

Let α, δ, be the star's right-ascension and declination at the time $t + 1855$, referred to the co-ordinate planes of 1855; α' and δ' being the right-ascension and declination for the same time, referred to its own co-ordinate-planes.

Then, if we vary the assumed AR. for 1855 by η and the assumed proper motion in AR. for n years by η'; the assumed Dec. for 1855 by ι, and the assumed proper motion in Dec. for n years by ι'; we shall have

$$\Delta \alpha = \eta + \frac{\eta' t}{n}, \qquad \Delta \delta = \iota + \frac{\iota' t}{n}.$$

[In our calculations we shall make $n = 30$.]

Again (*Fundamenta Astronomiæ*, p. 304 (15)).

$$\Delta \alpha' = \Delta \alpha (\cos \theta + \sin \theta \, tg \, \delta' \cos (\alpha' + \lambda' - z')) + \frac{\Delta \delta}{\cos \delta} \frac{\sin \theta \sin (\alpha' + \lambda' - z')}{\cos \delta'},$$

$$\Delta \delta' = - \Delta \alpha \sin \theta \sin (\alpha' + \lambda' - z') + \frac{\Delta \delta}{\cos \delta} \cos \delta' (\cos \theta + \sin \theta \, tg \, \delta' \cos (\alpha' + \lambda' - z')).$$

The notation here used is that of the Fundamenta.

Let

$$\sin \theta \sin (\alpha' + \lambda' - z') = m \sin \xi,$$

$$\cos \theta \cos \delta' + \sin \theta \sin \delta' \cos (\alpha' + \lambda' - z') = m \cos \xi,$$

taking the quadrant of ξ, so that m shall be positive.

We shall readily find (*Fundamenta*, p. 300 (9))

$$\sin \delta = \cos \theta \sin \delta' - \sin \theta \cos \delta' \cos (\alpha' + \lambda' - z'),$$

$$\sin \delta^2 + m^2 = \sin \delta^2 + m^2 \sin \xi^2 + m^2 \cos \xi^2 = 1.$$

Hence,

$$m^2 = \cos \delta^2 \text{; } m \text{ (always positive)} = \cos \delta,$$

$$\sin \xi = \frac{\sin \theta \sin (\alpha' + \lambda' - z')}{\cos \delta},$$

and

$$\varDelta \alpha' \cos \delta' = \varDelta \alpha \cos \delta \cos \xi + \varDelta \delta \sin \xi,$$

$$\varDelta \delta' = - \varDelta \alpha \cos \delta \sin \xi + \varDelta \delta \cos \xi.$$

Hence, again,

$$\varDelta \alpha' \cos \delta' = \left(\eta + \frac{\eta' t}{30}\right) \cos \delta \cos \xi + \left(\iota + \frac{\iota' t}{30}\right) \sin \xi,$$

$$\varDelta \delta' = - \left(\eta + \frac{\eta' t}{30}\right) \cos \delta \sin \xi + \left(\iota + \frac{\iota' t}{30}\right) \cos \xi.$$

If η η', ι ι' be of the nature of corrections to the assumed place, and $\varDelta \alpha' \cos \delta'$, $\varDelta \delta'$ be of an *opposite* character, — that is, be "computed — observed," — we must necessarily change the sign of one term; or, what is the same, transfer $\varDelta \alpha' \cos \delta'$, $\varDelta \delta'$ to the right members of their proper equations.

We have now the form of the equations of condition; perfectly rigorous. It is, however, obvious that in most cases perfect rigor is not necessary. For example, for stars near the equator no one would think of considering the declinations of 1755 as so erroneous that a perfectly accurate reduction of AR. to 1855 could not be effected by its means.

The rigorous course has here been followed for the four stars for which the value of sin ξ was the largest. These stars are λ Ursæ Minoris (Bode), 51 Cephei Hevelii, 4 Ursæ Minoris (Bode) and 20 Ursæ Minoris (Bode).

For the remaining stars of our polar list, a value of ι, ι' was deduced from the observed declinations, assuming that η, η' were $= 0$. Substituting these values in the equations derived from the right-ascensions observed, the values of η, η' were now obtained; employing in both cases the method of least squares, as will be further explained in its place.

These values of η, η' were now substituted in the declination equations, and a new set of values of ι, ι', differing by very small amounts from the former, were obtained.

The effect of these corrections was in no case over $0''.01$, when substituted in the right-ascension equations; so that the former values of η, η' were retained.

This process is equivalent simply to this: the computed declinations derived from our final theory are virtually employed to reduce the observed right-ascensions to 1855.0, and the resulting right-ascensions treated by the method of least squares give the final values of right-ascension and proper motion.

It remains to explain the details of the application of the method of least squares. For the four stars treated rigorously we have

$$\frac{\eta}{15} = w, \qquad \frac{\eta'}{15} = x, \qquad \iota = y, \qquad \iota' = z.$$

The assumed weights are denoted by ω for right-ascension, by ω' for declination. These were assigned in a somewhat arbitrary manner; bearing in mind the magnifying power of the various instruments employed, and in one or two instances the less than usual care bestowed on observation and reduction. It is possible that the weight which has been assigned is in some cases too large or too small; thus Bradley's observations have received a weight which, though small in itself, is yet rather larger than the probable error as given in the Fundamenta would seem to warrant. This, however, if an error, is but a venial one, as the Fundamenta are justly considered as entitled to a very large proportional weight.

In all cases where many observations have been made at the same observatory and with the same instrument, less than the proportional weight has been given. The maximum weight has been put at 3, while the minimum for a single observation has been $\frac{1}{8}$.

We shall now make in AR.

$$a = \sqrt{\omega}\; 15 \cos \delta \cos \xi,$$

$$b = a\,\frac{t - 1855}{30} = \frac{a\,t}{30} \text{ [if } t \text{ be counted from 1855]},$$

$$c = \sqrt{\omega} \sin \xi,$$

$$d = c\,\frac{t - 1855}{30} = \frac{c\,t}{30} \text{ [if } t \text{ be counted from 1855]},$$

$$n = \sqrt{\omega}\, \Delta\alpha' \cos \delta' \text{ [taking } \Delta\alpha' \text{ in the sense } c - o\text{]}.$$

And in declination

$$a = -\sqrt{\omega'}\; 15 \cos \delta \sin \xi,$$

$$b = \frac{a\,t}{30},$$

$$c = \sqrt{\omega'}\ \cos \xi,$$

$$d = \frac{c\,t}{30},$$

$$n = \sqrt{\omega'}\ \Delta\,\delta';\ (c - o).$$

The equations of equal precision for these four stars will be of the form

$$0 = n + a w + b x + c y + d z,$$

whose solution by least squares is a mere matter of mechanical computation, according to Encke's form in the Jahrbuch for 1836.

For the polar stars excepting these four we shall put

$$x = \eta \cos \delta, \qquad x' = \iota,$$

$$y = \eta' \cos \delta, \qquad y' = \iota',$$

and the quantities $x\ y$ will be eliminated from the declination equations, and $x'\ y'$ from those in right-ascension by the process mentioned above. We have, then, making

$$a = \sqrt{\omega} \cos \xi, \text{ or } \sqrt{\omega'} \cos \xi, \qquad \Delta\,n\ (\text{AR.}) = \sqrt{\omega}\left[\iota + \frac{\iota' t}{30}\right] \sin \xi,$$

$$b = a\,\frac{t}{30}, \qquad \Delta\,n\ (\text{Dec.}) = -\sqrt{\omega'}\left[\eta + \frac{\eta' t}{30}\right] \sin \xi \cos \delta',$$

the following equations of equal precision in right-ascension

$$0 = n + \Delta\,n + a x + b y = n' + a x + b y,$$

and in declination

$$0 = n + \Delta\,n + a x' + b y' = n' + a x' + b y'.$$

The process of forming these is, — 1st, assume in declination $\Delta\,n = 0$, and form and solve the declination-equations; 2d, substitute these values of x', y' or ι, ι' in the equation for $\Delta\ n$ in AR., and form and solve the right-ascension equations. This gives the means of correcting the declination-equations. These last corrections were shown by trial to have no perceptible effect on the equations for AR., and the process of approximation ceased here.

Tables III. and IV. contain the formation and solution of the equations. In order to add new equations in future, we must, after determining the weights, compute for the epoch in question the theoretical AR. and Dec. derived from the numbers in Table I.

Comparing these with the new observations, as in Table II., the quantities $\Delta\,\alpha'$, $\Delta\,\alpha'\cos\delta'$, $\Delta\,\delta'$ will be readily formed. If the star be one of the four strictly treated, the equations can be at once formed, by the formulæ for that purpose. Then the quantities $a\,n$, $b\,n$, $c\,n$, $d\,n$, etc., as also $a\,a$, $a\,b$, $a\,c$, etc., being computed for each new equation, and added in the proper place; the final equations in Table III. Part I. being

$$0 = [a\,n] + [a\,a]\,w + [a\,s]\,x + [a\,c]\,y + [a\,d]\,t,$$
$$0 = [b\,n] + [a\,b]\,w + [b\,b]\,x + [b\,c]\,y + [b\,d]\,z,$$
$$\text{etc.,} \qquad \text{etc.,}$$

will give at once new final equations which can be solved.

For the 21 other stars, the corrections in declination must first be computed, according to the values of x' and y' given in Table III. Part II.; after this is done, the quantity $\Delta\,n$ for the new equations in AR. can be formed, and their solution will present no difficulty. It will in general make no difference whether the new values of x and y, or those already given in Table III. Part II. be used, to obtain $\Delta\,n$ for declination. In either case there will be no difficulty in computing $\Delta\,n$ for the new observations, and thus forming the new equations according to the precepts for the old.

An extreme case may occur, where it will be found that $\Delta\,n$ for AR. would differ by a sensible amount when computed according to the new values of x' and y'. This, however, will not happen for a good many years.

It remains merely to explain Tables V., VI., which contain the calculations of AR. for the clock-stars. (Table VI., Supplement, contains the positions of the more northern stars not often used as clock-stars.)

The method here pursued was, to form positions for the years 1838–40, 1850, 1854–1858, and in some few cases for 1859, depending on the places of the Fundamenta for 1755, and the "Greenwich Results" for 1855. The positions of the Fundamenta were assumed as correct systematically, because the mean difference between the former reduction and Le Verrier's and Peters's new reductions of the 36 stars called "fundamental" is almost precisely zero; and so far as the casual errors of Bessel's places are concerned, it seemed possible to diminish their influence in great part by using comparatively late modern observations.

One of the objects of the observations now in progress at Cambridge, for the reduction of which these tables are designed, is to deduce new places of the fundamental stars, and to afford materials for a thorough examination of the relative systematic errors, whatever they may be, of the fundamental catalogue employed, so that for our purpose it is best to have a catalogue which is symmetrical as far as may be; which would not

be the case if we made a doubtful application of the method of least squares. The method here employed is the best I could devise for bringing down the relative errors of near stars.

The form of reduction proposed, and to some extent actually carried out, will enable the following things to be done with great ease: firstly, to reduce (if desired) the observations of each star so as to depend directly on the *Tabulae Reductionum*, and, secondly, to re-compute from our own observations the places of all the stars of the present list, so as to depend solely on our own observations, so far as our instrumental means will permit.

The positions derived from the Greenwich results for 1855, compared with Bessel's for 1755, will, assuming the correctness of the latter, require the addition of $x\,\frac{(t-1755)}{100}$, where x is a correction applicable to the places for 1855.

The positions given in the Edinburgh observations of 1838, 1839, 1840 were compared then with our calculated places, and would give in the mean the quantity

$$0.84\,x = \left(\frac{1839-1755}{100}\right)x,$$

after correcting them, to reduce to the equinox of Wolfers. See *Tabulae Reductionum*, p. xliii., at bottom, where we find

$$\text{N. C.} - \text{Henderson} = +\,0^{s}.038 \text{ (for 1830)}.$$

Reducing this to 1839, the mean epoch of the observations used

$$\text{N. C.} - \text{Henderson} = 0^{s}.043 \text{ (for 1835)}.$$

The number $+\,0^{s}.044$ was used instead; the change will be insensible.

The Edinburgh observations after 1840 were not used. The same catalogue had been employed to reduce them that was also employed at Greenwich for the same year, and the resulting numbers (it was feared) were not precisely homogeneous with those of the former years. The few observations made at Edinburgh on the new list of 47 stars introduced in 1857 into the Nautical Almanac were omitted. The Greenwich catalogue for 1850, depending, as is well known, upon the two instruments employed at Greenwich, — the old Transit and the new Transit-Circle, — was also compared. The Greenwich observations from 1854 to 1858 were compared; after the work was nearly complete, the volume for 1859 was received, and used for a few stars inadequately observed in the preceding years.

The Paris observations of 1856 and 1857 were also used. To my great regret, the

volumes for 1858 and 1859 did not come to hand till after the completion of the computations. The corrections for equinox here used were

Gr. C. 1850	$+0^{s}.017$,
Gr. Obs. 1854 — 1859	$+0^{s}.027$,
Paris	$+0^{s}.056$.

The mean of the corrected deviations of these four catalogues from the computed places, gives the correction x° for the mean t° of the dates. This was reduced to 1855 by the formula $x = x^\circ \frac{100}{t^\circ - 1755}$, the correction x was applied to the assumed places for 1855 (the Greenwich results 1855), and the right-ascensions of Table VI. formed. The annual variation given here is that which results from the combination of the mean annual variation derived from these right-ascensions compared with Bessel's Bradley, with the secular variation of the last column; which had been computed.

For the 47 stars given by Wolfers the positions are derived from the materials of his work, and are here computed for convenience' sake.

TABLE I.

Star's Name.	α°	h°	δ°	t°
43 Cephei Hevelii	12 24 6.64	+0.95	85 28 36.24	
Groombridge 527	36 47 36.39	+0.40	80 49 47.09	—0.10
323 Cephei (Bode)	49 48 50.00	+2.00	86 10 45.30	—0.05
Groombridge 750	58 6 11.20		85 9 51.60	
64 Camelopardali (Bode) . .	78 59 48.00		85 6 24.30	
51 Cephei Hevelii	97 46 45.00		87 15 9.00	
4 Ursæ Minoris (Bode) . .	105 55 0.00		89 1 49.00	
25 Camelopardali Hevelii . .	105 4 25.50		82 40 32.10	
156 Camelopardali (Bode) .	115 24 0.00		84 27 39.00	
1 Draconis Hevelii	139 0 30.00		81 57 38.50	
30 Camelopardali Hevelii . .	153 14 51.00		83 17 32.50	
202 Camelopardali (Bode) .	170 22 50.00	—0.75	81 55 29.10	
5 Ursæ Minoris (Bode) . .	183 0 50.42	+4.70	87 14 31.09	
6 Ursæ Minoris (Bode) . .	183 38 16.24	—1.75	88 30 5.72	+0.08
214 Camelopardali (Bode) .	200 12 12.50	—1.30	85 30 45.00	
20 Ursæ Minoris (Bode) . .	211 17 0.00		86 27 5.00	
57 Ursæ Minoris (Bode) . .	231 30 0.00		87 46 50.00	
62 Ursæ Minoris (Bode) . .	239 42 0.00		83 22 42.00	
ε Ursæ Minoris	255 14 30.66	+0.15	82 16 6.56	
λ Ursæ Minoris (Bode) . . .	302 9 38.49	—1.17	88 52 31.29	+0.01
74 Draconis	309 24 14.64	+0.40	80 34 28.12	+0.26
119 Cephei (Bode)	321 14 53.97	+0.06	83 38 36.08	—0.04
34 Cephei Hevelii	341 58 45.22		82 22 58.20	+0.05
39 Cephei Hevelii	351 55 24.42	+1.15	86 30 26.79	
309 Cephei (Bode)	358 11 50.56	+0.25	85 53 56.80	

TABLE II.

4 Ursæ Minoris (Bode). = Gr. 1119.

[sec δ′ for 1815 = 61.2; for 1855 = 59.1.]

	Δα′	Δα′ cos δ′	*N*	ω	Δδ′	*N*	ω′
Gr. 1807					−0″.22	9	½
Str. 1815	+ 9″.35	+0″.15	15	1			
Schw. 1828 . . .	−22.85	−0.37	2	¼	+0.91	2	¼
Pond, 1830 . . .	[−120.55]		4		−0.36	10	½
Hend. 1839 . . .	+ 1.25	+0.02	10	1	−0.72	10	1
Rob. 1844	+12.15	+0.20	30	2	−0.44	11	1
Joh. 1849, 1850 . .	+ 6.95	+0.12	70	3	−0.43	43	3
Airy, 1857	+43.80	+0.73	5	½	−0.50	5	½
Car. 1855	+ 6.00	+0.10	27	1½	−0.50	27	1½

λ Ursæ Minoris (Bode).

[sec δ′ for 1815 = 45.8; for 1855 = 51.0.]

Br. 1755	0″.00	0″.00	3	¼	0″.00	3	¼
Gr. 1807					+0.84	19	1
Str. 1815	+19.02	+0.42	4	½			
Schw. 1828 . . .	+17.48	+0.36	22	1	+0.01	12	1
Arg. 1830	+10.80	+0.22	17	1	+0.14	17	2
Pond, 1830 . . .	+10.80	+0.22	6	¼	+0.24	10	½
Airy, 1840 . . .	−14.11	−0.28	25	2	+0.03	77	3
Rob. 1843, 1852 . .	+17.75	+0.36	36	2	−0.42	5	1
Hend. 1840 . . .	− 5.05	−0.10	26	2	−0.01	132	3
Joh. 1843, 1847 . .	+ 5.43	+0.11	111	3	+0.42	158	3
Airy, 1844	−13.50	−0.27	15	1	+0.14	56	3
Airy, 1851	− 9.97	−0.20	49	2	−0.10	106	3
Airy, 1857	− 3.79	−0.07	63	3	+0.16	97	3
LeV. 1857 . . .	+11.79	+0.23	50	3	−0.25	59	3

6 Ursæ Minoris (Bode). = Gr. 1884.

[sec δ′ for 1815 = 45; for 1855 = 38.4.]

Br. 1752	0″.00	0″.00	4	¼	0″.00	4	¼
Gr. 1807					−0.47	6	½
Str. 1815	+18.55	+0.41	19	1			
Bessel, 1815 . . .					+0.02	24	1
Schw. 1828 . . .	+24.04	+0.56	11	¾	+0.26	10	¾
Arg. 1830	+24.84	+0.58	16	1	+0.44	10	1
Hend. 1839 . . .	+42.09	+1.03	10	1	−0.26	10	1
Airy, 1840	−23.98	−0.56	5	½			
Rob. 1839	+26.02	+0.64	59	3	−0.22	18	1½
Airy, 1842	+ 8.53	+0.21	4	½	+0.91	7	1
Joh. 1848	−11.54	−0.29	63	3	+0.48	67	3
Airy, 1851	− 8.28	−0.21	3	½	−0.74	3	½
Car. 1855	−10.26	−0.27	15	1	+0.52	15	1

57 φ Ursæ Minoris (Bode). = Gr. 2283.

[sec δ′ for 1815 = 27.4 ; for 1855 = 25.8.]

	Δα′	Δα′ cos δ′	N	ω	Δδ′	N	ω′
Gr. 1808					+1″.58	8	½
Str. 1815	+11″.17	+0″.41	13	1			
Schw. 1828 . . .	+ 8.89	+0.33	5	½	+0.85	5	½
Hend. 1839 . . .	+13.18	+0.50	10	1	+0.14	10	1
Joh. 1850	—19.13	—0.73	47	3	—0.54	11	1
Airy, 1851	+ 6.75	+0.26	5	½	+0.40	4	½
Car. 1855	+ 4.50	+0.17	12	1	—0.60	12	1

5 Ursæ Minoris (Bode). = Gr. 1871.

[sec δ′ for 1815 = 22.6 ; for 1855 = 20.8.]

	Δα′	Δα′ cos δ′	N	ω	Δδ′	N	ω′
Br. 1751	0″.00	0″.00	2	⅕			
Gr. 1807					—1″.49	7	½
Str. 1815	— 8.37	—0.37	17	1			
Schw. 1828* . . .	+ 4.57	+0.21	2	¼	—0.78	2	¼
Arg. 1830	+10.25	+0.47	19	1½	+0.61	19	2
Airy, 1840	+ 1.12	+0.05	6	½	—0.08	12	1
Joh. 1850	+ 1.15	+0.05	28	2	—0.43	8	1
Airy, 1851	+ 6.08	+0.29	4	½	—0.04	5	½
Car. 1855	+17.92	+0.86	5	½	—0.41	5	½

51 Cephei Hevelii.

[sec δ′ for 1815 = 21.0 ; for 1855 = 20.9.]

	Δα′	Δα′ cos δ′	N	ω	Δδ′	N	ω′
Gr. 1807					—1″.48	11	½
Str. 1815	— 6″.57	—0″.31	14	1			
Schw. 1828 . . .	— 7.24	—0.35	17	1	—0.63	14	1
Pond, 1830† . . .	— 2.37	—0.11	23	1	+0.70	20	1
Hend. 1842 . . .	+ 6.20	+0.30	29	2	—0.31	108	3
Airy, 1840	+ 7.67	+0.37	17	1	+0.49	78	3
Airy, 1843	+16.47	+0.78	33	2	—0.30	40	2
Joh. 1847	— 0.42	—0.02	157	3	—0.37	122	3
Airy, 1850	+ 8.08	+0.39	50	2	+0.28	66	2½
Airy, 1857	+10.67	+0.51	100	3	+0.56	185	3
LeV. 1857 . . .	—18.54	—0.88	3	¼	+1.46	1	
Car. 1855	+ 5.70	+0.27	28	2	+0.28	28	2

20 Ursæ Minoris (Bode). = Gr. 2099.

[sec δ′ for 1815 = 17.0 ; for 1855 = 16.1.]

	Δα′	Δα′ cos δ′	N	ω	Δδ′	N	ω′
Gr.					+0″.72	5	½
Str. 1815	—10″.54	—0″.62	12	1			
Schw. 1828* . . .	— 8.33	—0.50	3	⅓	+1.62	3	⅓
Joh. 1850, 1852 . .	— 2.43	—0.15	20	2	—0.21	7	¾
Car. 1855	+25.50	+1.59	4	½	—2.20	4	½

* See Carrington.

† Declination derived from observations of 1833 alone. Those of 1831, which differ in the mean 3″.11 from those of 1833, are excluded.

39 Cephei Hevelii.

[sec δ′ for 1815 = 15.4 ; for 1855 = 16.4.]

	Δα′	Δα′ cos δ′	N	ω	Δδ′	N	ω′
Br. 1755	0″.00	0″.00	4	¼	0″.00	5	¼
Gr. 1808					+1.71	6	½
Str. 1815	+21.53	+1.40	3	⅕			
Schw. 1828 . . .	+ 1.48	+0.09	7	½	+0.12	6	½
Hend. 1839 . . .	+ 4.24	+0.26	11	1	—0.19	10	1
Airy, 1840	—12.68	—0.79	5	½			
Rob. 1839, 1842 . .	+18.49	+1.16	13	1	+0.55	5	½
Airy, 1842	— 0.04	0.00	5	½	—0.55	5	½
Joh. 1850	+ 0.01	0.00	38	2½	+0.95	31	2
Airy, 1851, 1852 .	— 6.53	—0.40	5	½	+0.71	10	1
Car. 1855	— 3.08	—0.19	21	2	—0.81	21	½

323 Cephei (Bode). = Gr. 642.

[sec δ′ for 1815 = 14.4 ; for 1855 = 15.0.]

Gr. 1807					+0″.23	6	½
Str. 1815	+25″.68	+1″.78	19	1			
Schw. 1828	— 0.54	—0.04	8	½	—0.48	7	¾
Airy, 1840							
Hend. 1839 . . .	+ 2.71	+0.18	10	1	—0.65	10	1
Airy, 1845	— 6.54	—0.46	3	¼	—0.43	5	½
Joh. 1845, 1850 . .	+ 8.39	+0.57	50	3	+0.39	14	1¼
Airy, 1851	+ 4.35	+0.29	5	½	+0.34	4	½
Car. 1855	+ 1.00	+0.07	5	½	—0.50	5	½

43 Cephei Hevelii = 2 Ursæ Minoris. = Gr. 177.

[sec δ′ for 1815 = 12.1 ; for 1855 = 12.7.]

Br. 1755	0″.00	0″.00	8	⅜	0″.00	5	⅓
Gr. 1807					+0.24	7	½
Str. 1815	+ 5.28	+0.42	6	⅝			
Bess. 1815					—0.45	28	1
Schw. 1828 . . .	+ 1.28	+0.10	3	¼	—0.66	2	¼
Pond, 1830 . . .	— 3.78	—0.31	10	½	+0.52	12	⅔
Airy, 1837	— 5.98	—0.48	5	½			
Hend. 1839 . . .	— 2.83	—0.23	7	¾	+0.01	16	1½
Rob. 1837, 1852 . .	+ 2.37	+0.19	8	¾	+1.57	2	¼
Airy, 1845					+0.66	7	¾
Joh. 1849, 1851 . .	— 1.60	—0.12	24	2	+0.65	12	1
Airy, 1851	—12.01	—0.95	4	½	—0.24	4	½
Car. 1855	— 1.86	—0.15	3	¼	—0.26	3	¼

309 Cephei (Bode). = Gr. 4193.

[sec δ′ for 1815 = 13.3 ; for 1855 = 14.0.]

	Δα′	Δα′ cos δ′	N	ω	Δδ′	N	ω′
Br. 1755	0″.00	0″.00	2	⅛			
Gr. 1808					−0″.34	6	½
Str. 1815	+12.20	+0.91	3	¼			
Bess. 1815					−1.21	27	1
Schw. 1828 . . .	+13.45	+1.00	2	¼	+0.27	2	¼
Rob. 1844, 1846 . .	− 0.87	−0.06	5	½	+1.10	5	½
Joh. 1849	− 8.88	−0.64	29	2	+0.44	18	1½
Airy, 1851	−11.62	−0.84	8	1	−0.03	10	1
Car. 1855	−12.94	−0.92	4	½	−1.80	4	½

214 Camelopardali (Bode). = Gr. 2007.

[sec δ′ for 1815 = 13.4 ; for 1855 = 12.8.]

Gr. 1808					+0″.86	6	½
Str. 1815	+3″.51	+0″.26	4	½			
Schw. 1828 . . .	−1.17	−0.09	2	¼	−1.32	2	¼
Hend. 1839 . . .	+3.63	+0.28	10	1	−0.42	10	1
Airy, 1845 . . .					−0.59	5	½
Joh. 1849, 1850 . .	−3.16	−0.24	29	2½	+1.40	22	2
Airy, 1850, 1851 .	−1.51	−0.12	8	¾	−0.62	7	¾
Car. 1855	+1.00	+0.08	3	¼	−1.80	3	¼

Gr. 750.

[sec δ′ for 1815 = 11.6 ; for 1855 =11.9.]

Gr. 1808					+1″.66	6	½
Str. 1815	+3″.12	+0″.28	5	½			
Schw. 1828 . . .	+1.75	+0.14	2	¼	−0.62	2	¼
Pond. 1830 . . .	−1.67	−0.14	11	¾	+1.06	13	¾
Hend. 1839 . . .	−2.52	−0.21	10	1	−0.47	10	1
Joh. 1848, 1852 . .	+3.00	+0.25	43	3	−0.59	11	1
Airy, 1857	−3.25	−0.27	5	½	+0.08	7	1
Car. 1855	−5.30	−0.45	16	1½	−0.90	16	1

156 Camelopardali (Bode). = Gr. 1359.

[sec δ′ for 1815 = 10.5 ; for 1855 = 10.4.]

Gr. 1808					+0″.96	7	½
Str. 1815	+ 3″.57	+0″.34	3	¼			
Schw. 1828 . . .	+ 4.05	+0.39	7	¾	+0.44	7	¾
Hend. 1844 . . .	+14.26	+1.36	5	¾			
Joh. 1850, 1848 . .	+ 1.54	+0.15	38	2½	+0.50	23	2
Airy, 1844	+ 7.09	+0.68	4	½	−0.11	3	¼
Carr. 1855	−10.50	−1.01	3	¼	−0.40	3	¼

64 Camelopardali (Bode). = Gr. 944.
[sec δ′ for 1815 = 11.6; for 1855 = 11.7.]

	Δα′	Δα′ cos δ′	N	ω	Δδ′	N	ω′
Gr. 1807					+0″.14	6	½
Str. 1815	+14″.75	+1″.27	8	¾			
Schw. 1828 . . .	+ 0.53	+0.05	5	½	+1.02	5	½
Hend. 1839 . . .	+ 3.90	+0.33	10	1	−0.58	11	1
Rob. 1850, 1851 . .	− 5.26	−0.47	2	¼	+1.66	5	½
Joh. 1848, 1846 . .	− 1.12	−0.10	33	2½	−0.09	18	1½
Airy, 1844	+ 5.18	+0.44	4	½	+0.02	5	½
Airy, 1851	+ 4.95	+0.42	3	½	−0.14	3	½
Car. 1855	0.00	0.00	14	1¼	−0.70	14	1

119 Cephei (Bode).*
[sec δ′ for 1815 = 8.8; for 1855 = 9.0.]

Br. 1755	0″.00	0″.00	2	⅛	0″.00	1	⅛
Gr. 1808					+2.59	7	½
Str. 1815	+10.42	+1.18	1	⅛			
Schw. 1828 . . .	+ 5.58	+0.63	2	¼	+0.57	2	¼
Rob. 1846, 1849 . .	− 7.22	−0.81	5	½	+0.13	5	½
Joh. 1851, 1848 . .	− 1.31	−0.15	5	½	+0.65	3	½
Car. 1855	− 6.03	−0.67	3	¼	−1.52	3	¼

2315 Groombr. = 62 Ursæ Minoris (B).
[sec δ′ for 1815 = 8.8; for 1855 = 8.7.]

Gr. 1807					+0″.74	6	½
Str. 1815	+ 1″.64	+0″.19	6	½			
Schw. 1828 . . .	+13.48	+1.55	2	¼	−0.31	2	¼
Airy, 1847					+1.43	2	½
Joh. 1851, 1850 . .	− 3.18	−0.37	4	½	+0.68	6	½
Airy, 1850	− 4.75	−0.55	2	¼			
Car. 1855	− 6.00	−0.69	3	¼	−1.10	3	¼

30 Camelopardali Hevelii. = Gr. 1633 = P. X. 22.
[sec δ′ for 1855 = 8.8; for 1855 = 8.6.]

Gr. 1807					+0″.34	6	½
Str. 1815	−13″.31	−1″.51	2	¼			
Schw. 1828 . . .	+ 8.89	+1.01	4	½	+0.83	4	½
Rob. 1844 1854 . .	+15.86	+1.83	5	½.	+0.85	5	½
Joh. 1845	+ 8.45	+0.98	7	¾	+0.52	6	¾
Airy, 1847					−0.64	9	1
Airy, 1850	+13.24	+1.54	9	1	+0.17	20	2
Car. 1855	+18.00	+2.09	3	¼	−1.10	3	¼

* 13″.2, or one division, has been subtracted from the declination in the *Fundamenta Astronomiae.* The correction seems necessary.

25 Camelopardali Hevelii. = Gr. 1259.

[sec δ′ for 1815 = 7.9 ; for 1855 = 7.84.]

	Δα′	Δα′ cos δ′	N	ω	Δδ′	N	ω′
Gr. 1808					−0″.54	6	½
Str. 1815	−0″.59	−0″.07	3	¼			
Str. 1824	+0.31	+0.04	14	1½	−0.21	14	1
Schw. 1828 . . .	−0.24	−0.03	19	1¼	+0.08	17	1½
Pond, 1830 . . .	−10.65	−1.36	10	¾	+0.10	11	¾
Airy, 1840	−0.80	−0.10	5	½	−0.18	16	1½
Rob. 1831, 1852 . .	−7.85	−1.00	2	¼	+2.28	5	½
Airy, 1844	+5.19	+0.66	4	½	−0.13	3	¼
Joh. 1843 . . .	−9.52	−1.22	5	½	+0.98	7	¾
Airy, 1849					−0.63	5	½
Car. 1855	−12.00	−1.53	3	¼	0.00	3	¼
Airy, 1858					+1.41	2	¼

34 Cephei Hevelii.

[sec δ′ for 1815 = 7.34 ; for 1855 = 7.55.]

	Δα′	Δα′ cos δ′	N	ω	Δδ′	N	ω′
Br. 1755	0″.00	0″.00	1	⅙	0″.00	3	¼
Gr. 1808					+0.53	6	½
Str. 1815	+14.68	+2.00	1	¼			
Schw. 1828 . . .	+5.52	+0.74	9	⅚	−0.26	8	¾
Rob. 1842, 1843 . .	−1.51	−0.20	10	1	−0.04	10	1
Airy, 1839	−6.01	−0.81	6	½			
Airy, 1846					−0.36	3	⅖
Joh. 1847, 1844 .	+1.34	+0.18	4	½	+0.97	6	½
Car. 1855	−5.78	−0.77	3	¼	−1.50	3	¼

ε Ursæ Minoris.

[sec δ′ for 1815 = 7.49 ; for 1855 = 7.43.]

	Δα′	Δα′ cos δ′	N	ω	Δδ′	N	ω′
Br. 1755	0″.00	0″.00	5	⅓	0″.00	5	⅓
Gr. 1807					+0.36	16	1
Str. 1815	+2.71	+0.36	38	2			
Str. 1824	−1.71	−0.23	15	2	−0.19	15	2
Schw. 1828 . . .	+2.58	+0.35	29	1	−0.32	18	1
Pond, 1830 . . .	+1.62	+0.22	9	½	−0.19	12	½
Hend. 1841 . . .	−0.87	−0.12	19	1½	+0.11	99	3
Airy, 1840	−4.84	−0.65	28	2	−0.21	102	3
Rob. 1828, 1836 . .	+18.78	+2.50	2	¼	−0.11	4	½
Peters, 1840 . . .	−4.09	−0.55		3			
Airy, 1845	−8.19	−1.10	22	1½	+0.09	84	3
Joh. 1842, 1843 .	+1.19	+0.16	19	1½	−0.11	24	3
Airy, 1851	−3.96	−0.53	40	2½	−0.11	64	3
Car. 1855	−0.84	−0.11	3	¼	−1.14	3	¼
Airy, 1857	+1.16	+0.16	45	3	+0.14	72	3
LeV. 1857 . . .	+5.43	+0.73	16	2	−0.28	38	2

202 Camelopardali (Bode).

[sec δ′ for 1815 = 7.3 ; for 1855 = 7.1.]

	Δα′	Δα′ cos δ′	N	ω	Δδ′	N	ω′
Gr. 1807					+1″.00	6	½
Str. 1815	+0″.41	+0″.06	3	⅓			
Schw. 1828 . . .	+5.13	+0.70	7	⅔	+0.05	5	½
Joh. 1844, 1846 .	+3.53	+0.50	5	½	+0.78	5	½
Car. 1855	—1.00	—0.14	3	¼	—1.00	3	¼

1 Draconis Hevelii. = Gr. 1537.*

[sec δ′ for 1815 = 7.3 ; for 1855 = 6.95.]

	Δα′	Δα′ cos δ′	N	ω	Δδ′	N	ω′
Gr. 1810					+0″.38	6	½
Str. 1815	— 1″.90	—0″.26	6	¾			
Schw. 1828 . . .	— 0.26	—0.04	57	3	+0.18	46	3
Pond, 1830 . . .	— 6.50	—0.91	14	¾	+0.57	20	1
Peters, 1840 . . .	— 0.53	—0.08	16	2			
Airy, 1840	— 4.88	—0.69	5	½	+0.16	20	2
Airy, 1845	— 7.13	—1.01	6	½	+0.55	7	¾
Joh. 1845, 1850 . .	— 2.33	—0.33	5	½	+0.24	17	1½
Airy, 1851	— 0.23	—0.03	7	¾	+0.09	1	¼
Car. 1855	—10.50	—1.51	3	¼	+0.30	3	¼

Gr. 527.

[sec δ′ for 1815 = 6.15 ; for 1855 = 6.26.]

	Δα′	Δα′ cos δ′	N	ω	Δδ′	N	ω′
Br. 1755	0″.00	0″.00	1	⅕			
Gr. 1807					+0″.56	6	½
Str. 1815	— 3.48	—0.57	11	1			
Schw. 1828 . . .	+ 1.38	+0.23	7	¾	+0.14	7	7/10
Rob. 1853, 1850 . .	— 0.82	—0.13	3	⅗	+0.42	5	½
Airy, 1841					—1.35	2	3/10
Airy, 1847	+12.56	+2.01	2	¼			
Joh. 1844, 1846 . .	— 0.60	—0.10	3	¼	—0.31	5	½
Airy, 1849, 1850 .	+ 4.17	+0.67	2	¼	—0.27	9	1

74 Draconis.

[sec δ′ for 1815 = 6.02 ; for 1855 = 6.11.]

	Δα′	Δα′ cos δ′	N	ω	Δδ′	N	ω′
Br. 1755	0″.00	0″.00	2	¼	0″.00	4	3/10
Gr. 1808					+0.99	6	½
Str.† 1815	[+19.59]	+0.76	1				
Bess. 1818	+ 2.41	+0.40	2	⅓			
Schw. 1828 . . .	+13.26	+2.19	3	¼	+2.12	3	3/10
Arg. 1830	+ 7.06	+1.17	9	1	+1.76	9	1
Rob. 1853, 1842 . .	+ 2.33	+0.38	1	⅕	+3.58	7	⅘
Joh. 1850, 1846 . .	+11.71	+1.91	5	½	+3.50	7	⅗

* I have not been able to verify Robinson's declination from his observations.

† Probably one second of time in error (see Argelander).

TABLE III. Part 1.*

4 Ursæ Minoris (Bode) = Gr. 1119.

$0 = +0.2970 + 0.5950\,w - 0.2076\,x - 0.0284\,y + 0.0181\,z$	$w = -0^{s}.683$
$0 = -0.0520 - 0.2076\,w + 0.1674\,x + 0.0180\,y - 0.0107\,z$	$x = -0^{s}.576$
$0 = -3.5740 - 0.0284\,w + 0.0180\,x + 8.2660\,y - 2.7550\,z$	$y = +0''.515$
$0 = +0.8430 + 0.0181\,w - 0.0107\,x - 2.7550\,y + 2.3150\,z$	$z = +0''.252$

λ Ursæ Minoris (Bode).

$0 = +0.2000 + 1.8200\,w - 0.6210\,x - 0.0770\,y + 0.0660\,z$	$w = -0^{s}.070$
$0 = -0.1070 - 0.6210\,w + 0.6027\,x + 0.0650\,y - 0.0880\,z$	$x = +0^{s}.144$
$0 = +1.9550 - 0.0770\,w + 0.0650\,x + 24.4830\,y - 8.6580\,z$	$y = +0''.017$
$0 = -2.1960 + 0.0660\,w - 0.0880\,x - 8.6580\,y + 8.5800\,z$	$z = +0''.276$

57 φ Ursæ Minoris (Bode) = Gr. 2283.

$0 = -0.5390 + 2.3600\,w - 0.9560\,x + 0.0440\,y - 0.0260\,z$	$w = +0^{s}.642$
$0 = -0.2750 - 0.9560\,w + 0.8580\,x - 0.0260\,y + 0.0270\,z$	$x = +1^{s}.007$
$0 = +0.4250 + 0.0440\,w - 0.0260\,x + 4.5040\,y - 2.0130\,z$	$y = +0''.551$
$0 = -1.6060 - 0.0260\,w + 0.0270\,x - 2.0130\,y + 1.8700\,z$	$z = +1''.446$

51 Cephei Hevelii.

$0 = +2.6900 + 9.3030\,w - 3.1160\,x + 0.0410\,y - 0.0010\,z$	$w = -0^{s}.595$
$0 = +0.2230 - 3.1160\,w + 2.2790\,x - 0.0040\,y - 0.0130\,z$	$x = -0^{s}.916$
$0 = +1.1060 + 0.0410\,w - 0.0040\,x + 21.0020\,y - 6.9660\,z$	$y = -0''.295$
$0 = +1.2060 - 0.0010\,w - 0.0130\,x - 6.9660\,y + 4.4620\,z$	$z = -0''.734$

TABLE III. Part 2.†

6 Ursæ Minoris B.

$0 = +2.99 + 12.50\,x - 7.02\,y$	$x = -0.089$	$0 = +2.34 + 11.50\,x' - 7.20\,y'$	$x' = -0.324$
$0 = -2.63 - 7.02\,x + 7.51\,y$	$y = +0.268$	$0 = -0.72 - 7.20\,x' + 8.32\,y'$	$y' = -0.194$

5 Ursæ Minoris B.

$0 = +1.09 + 6.45\,x - 4.14\,y$	$x = -0.285$	$0 = -0.45 + 5.75\,x' - 3.41\,y'$	$x' = -0.007$
$0 = -0.20 - 4.14\,x + 5.43\,y$	$y = -0.181$	$0 = +0.41 - 3.41\,x' + 3.00\,y'$	$y' = -0.144$

39 Cephei Hevelii.

$0 = +0.83 + 9.00\,x - 3.63\,y$	$x = +0.004$	$0 = +2.12 + 7.75\,x' - 3.46\,y'$	$x' = -0.176$
$0 = -1.04 - 3.63\,x + 4.48\,y$	$y = +0.234$	$0 = -1.66 - 3.46\,x' + 4.82\,y'$	$y' = +0.219$

20 Ursæ Minoris B.

$0 = -0.32 + 3.83\,x - 1.64\,y$	$x = -0.233$	$0 = -0.36 + 2.08\,x' - 1.16\,y'$	$x' = +1.05$
$0 = +0.98 - 1.64\,x + 1.83\,y$	$y = -0.74$	$0 = -1.01 - 1.16\,x' + 1.41\,y'$	$y' = +1.58$

323 Cephei B.

$0 = +3.73 + 6.75\,x - 2.97\,y$	$x = -0.174$	$0 = -0.63 + 5.00\,x' - 2.63\,y'$	$x' = +0.146$
$0 = -2.73 - 2.97\,x + 2.58\,y$	$y = +0.86$	$0 = +0.29 - 2.63\,x' + 2.34\,y'$	$y' = +0.039$

309 Cephei B.

$0 = -2.14 + 4.62\,x - 1.70\,y$	$x = +0.68$	$0 = -1.03 + 5.25\,x' - 2.92\,y'$	$x' = -0.116$
$0 = -0.12 - 1.70\,x + 2.15\,y$	$y = +0.59$	$0 = +1.53 - 2.92\,x' + 3.33\,y'$	$y' = -0.561$

* In this portion of Table III. w denotes the correction in *time* of the assumed AR., and x 30 times the correction in time of the assumed annual proper motion; y in like manner denotes the correction in space of the assumed declination, and z 30 times the correction in space of its assumed annual proper motion; — all assumed values holding good for 1855.

† In this portion of Table III. x denotes the correction of the assumed right ascension for 1855, expressed in seconds of space and multiplied by the cosine of the declination; y denotes the correction of the assumed proper motion (for 1855) in AR., multiplied by 30 and by the cosine of the declination, — likewise, in space; x' and y' denote the same quantities as y and z in the first part of this table.

214 Camelopardali B.

$0 = -0.29 + 5.25x - 1.91y$ $x = +0.202$ $0 = +1.27 + 5.25x' - 2.24y'$ $x' = -0.238$
$0 = -0.20 - 1.91x + 1.45y$ $y = +0.404$ $0 = -0.55 - 2.24x' + 1.85y'$ $y' = +0.011$

43 Cephei Hevelii. (2 Ursæ Minoris.)

$0 = -0.92 + 6.50x - 4.22y$ $x = +0.246$ $0 = +0.57 + 8.00x' - 6.24y'$ $x' = -0.27$
$0 = -0.01 - 4.22x + 6.53y$ $y = +0.160$ $0 = +0.53 - 6.24x' + 8.73y'$ $y' = -0.25$

Gr. 750.

$0 = -0.20 + 7.50x - 2.02y$ $x = +0.085$ $0 = -0.41 + 5.50x' - 2.32y'$ $x' = +0.585$
$0 = -0.25 - 2.02x + 1.94y$ $y = +0.215$ $0 = -1.43 - 2.32x' + 2.29y'$ $y' = +1.203$

64 Camelopardali B.

$0 = +1.38 + 7.25x - 2.83y$ $x = +0.139$ $0 = -0.13 + 6.00x' - 2.52y'$ $x' = +0.157$
$0 = -1.48 - 2.83x + 2.21y$ $y = +0.847$ $0 = -0.29 - 2.52x' + 2.14y'$ $y' = +0.319$

156 Camelopardali B.

$0 = +1.83 + 5.00x - 1.83y$ $x = -0.21$ $0 = +1.65 + 3.75x' - 2.06y'$ $x' = -0.22$
$0 = -0.91 - 1.83x + 1.26y$ $y = +0.41$ $0 = -1.26 - 2.06x' + 2.01y'$ $y' = +0.40$

30 Camelopardali H.

$0 = +3.68 + 3.25x - 1.37y$ $x = -1.92$ $0 = +0.82 + 5.50x' - 2.10y'$ $x' = -0.01$
$0 = -0.75 - 1.37x + 1.01y$ $y = -1.86$ $0 = -0.69 - 2.10x' + 1.86y'$ $y' = +0.36$

119 Cephei B.

$0 = -0.37 + 1.75x - 1.02y$ $x = +0.38$ $0 = +1.44 + 2.12x' - 1.64y'$ $x' = -0.13$
$0 = -0.13 - 1.02x + 1.86y$ $y = +0.28$ $0 = -2.25 - 1.64x' + 2.88y'$ $y' = +0.71$

62 Ursæ Minoris B.

$0 = -0.03 + 1.75x - 0.99y$ $x = +0.45$ $0 = +1.08 + 2.00x' - 1.23y'$ $x' = -0.43$
$0 = -0.40 - 0.99x + 1.11y$ $y = +0.76$ $0 = -0.79 - 1.23x' + 1.50y'$ $y' = +0.18$

25 Camelopardali H.

$0 = -1.96 + 5.75x - 4.46y$ $x = +0.86$ $0 = +1.23 + 7.75x' - 5.09y'$ $x' = -0.77$
$0 = +1.14 - 4.46x + 4.02y$ $y = +0.67$ $0 = +0.45 - 5.09x' + 4.70y'$ $y' = -0.93$

34 Cephei H.

$0 = +0.46 + 3.37x - 2.20y$ $x = +0.09$ $0 = +0.03 + 3.65x' - 3.00y'$ $x' = +0.10$
$0 = -0.73 - 2.20x + 2.67y$ $y = +0.34$ $0 = -0.33 - 3.00x' + 4.80y'$ $y' = +0.13$

ε Ursæ Minoris.

$0 = -2.91 + 23.33x - 11.69y$ $x = +0.16$ $0 = -1.60 + 25.58x' - 11.49y'$ $x' = +0.08$
$0 = +0.91 - 11.69x + 12.80y$ $y = +0.08$ $0 = +0.47 - 11.49x' + 12.00y'$ $y' = +0.04$

202 Camelopardali B.

$0 = +0.72 + 1.75x - 1.22y$ $x = -0.29$ $0 = +0.66 + 1.75x' - 1.39y'$ $x' = +0.14$
$0 = -0.56 - 1.22x + 1.20y$ $y = +0.17$ $0 = -0.93 - 1.39x' + 1.71y'$ $y' = +0.66$

1 Draconis H.

$0 = -2.45 + 9.00x - 6.01y$ $x = +0.48$ $0 = -0.28 + 9.25x' - 5.88y'$ $x' = -0.30$
$0 = +1.39 - 6.01x + 5.03y$ $y = +0.29$ $0 = +0.18 - 5.88x' + 5.02y'$ $y' = \quad 0.00$

Gr. 527.

$0 = +0.19 + 3.00x - 2.64y$ $x = -0.45$ $0 = -0.24 + 3.50x' - 1.96y'$ $x' = +0.35$
$0 = +0.47 - 2.64x + 3.77y$ $y = -0.44$ $0 = -0.31 - 1.96x' + 1.98y'$ $y' = +0.51$

74 Draconis.

$0 = +2.99 + 2.62x - 2.64y$ $x = -1.71$ $0 = +7.75 + 3.50x' - 3.41y'$ $x' = -3.42$
$0 = -1.86 - 2.64x + 4.72y$ $y = -0.56$ $0 = -4.71 - 3.41x' + 5.61y'$ $y' = -1.24$

TABLE IV.

	AR.	log a	log b	log c	log d	μ	ν	Dec.	μ'	Mag.
	5 Ursæ Minoris B.									
	h m s					s	s	° ′ ″	″	
1855	12 12 34.30	0.1904	0.1404n	0.1409n	8.8806n	+0.306	+0.001	87 14 31.08	—0.005	6
1865	12 52.79	0.1886	0.1317n	0.1322n	8.8824n	+0.300	+0.001	11 10.79		
	6 Ursæ Minoris B.									
1855	12 14 21.19	*	0.4061n	0.4062n	9.2035n	—0.094	—0.007	88 30 13.40	+0.074	6
1865	14 19.56		0.3903n	0.3904n	9.1869n	—0.091	—0.006	26 53.97		
	43 Cephei Hevelii.									
1855	0 49 42.98	0.8267	9.9154	9.9167	9.2599	+0.068	—0.006	85 28 35.97	—0.001	4.5
1865	50 51.40	0.8349	9.9202	9.9215	9.2749	+0.068	—0.006	31 51.70		
	Polaris † (from Wolfers).									
1860	1 8 2.65							88 33 47.12		2
1865	9 38.10							35 22.91		
1870	11 16.92							36 58.48		
	214 Camelopardali B.									
1855	13 20 40.34	0.4474n	9.9017n	9.9030n	9.4680n	—0.075	—0.005	85 30 44.76	0.000	7.8
1865	20 12.08	0.4315n	9.8969n	9.8982n	9.4605n	—0.074	—0.005	27 36.43		
	20 Ursæ Minoris B. = Gr. 2099.									
1855	14 5 7.75	0.9098n	9.9632n	9.9641n	9.7477n	—0.027	—0.013	86 27 6.05	+0.053	7.8
1865	3 47.52	0.8959n	9.9590n	9.9598n	9.7577n	—0.027	—0.012	24 14.87		
	Gr. 527.									
1855	2 27 12.90	0.9048	9.5192	9.5248	9.3989	+0.021	—0.003	80 49 37.44	—0.083	6
1865	28 33.75	0.9083	9.5194	9.5249	9.4043	+0.020	—0.003	52 16.84		
	323 Cephei B.									
1855	3 19 28.49	1.2642	9.8083	9.8093	9.8835	+0.162	—0.016	86 10 40.45	—0.049	6
1865	22 35.44	1.2717	9.8053	9.8062	9.8924	+0.164	—0.016	12 48.17		
	57 Ursæ Minoris B.									
1855	15 26 0.64	1.3789n	0.0297n	0.0300n	0.1295n	+0.034	—0.040	87 46 50.55	+0.048	7
1865	22 5.61	1.3642n	0.0319n	0.0322n	0.1165n	+0.032	—0.039	44 44.85		
	Gr. 750.									
1855	3 52 24.81	1.2171	9.6195	9.6211	9.8270	+0.006	—0.009	85 9 52.18	+0.040	7
1865	55 10.61	1.2220	9.6136	9.6152	9.8329	+0.006	—0.009	11 37.53		

* a (number) —0ˢ.1314 for 1855, —0ˢ.0107 for 1865.

† Apparent Places from the *Berliner Astronomisches Jahrbuch.*

	AR.	log *a*	log *b*	log *c*	log *d*	μ	ν	Dec.	μ′	Mag.
	62 Ursæ Minoris B.									
	h m s					s	s	° ′ ″	″	
1855	15 58 48.26	0.8371*n*	9.4620*n*	9.4649*n*	9.6982*n*	+0.015	—0.004	83 22 41.57	+0.006	7.8
1865	57 40.04	0.8326*n*	9.4638*n*	9.4667*n*	9.6951*n*	+0.015	—0.004	21 0.01		
	ε Ursæ Minoris.									
1855	17 0 59.13	0.8097*n*	9.0971*n*	9.1011*n*	9.6805*n*	+0.011	—0.001	82 16 6.64	+0.001	4.5
1865	16 59 54.87	0.8076*n*	9.1039*n*	9.1079*n*	9.6792*n*	+0.011	—0.001	15 15.13		
	64 Camelopardali B.									
1855	5 15 59.31	1.2649	*	*	9.8849	+0.022	—0.004	85 6 24.46	+0.011	6
1865	19 3.91	1.2665			9.8869	+0.022	—0.003	7 1.52		
	δ Ursæ Minoris.†									
1860	18 17 30.16							86 36 6.24		4.5
1865	15 53.34							36 13.63		
1870	14 16.41							36 20.33		
	51 Cephei Hevelii.									
1855	6 31 6.40	1.4868	‡	‡	0.1392	—0.031	+0.008	87 15 8.70	—0.024	5
1865	36 12.01	1.4843			0.1365	—0.031	+0.009	14 39.12		
	25 Camelopardali Hevelii.									
1855	7 0 18.15	1.1178	9.1300*n*	9.1336*n*	9.7032	+0.012	+0.002	82 40 31.33	—0.031	5
1865	2 29.19	1.1162	9.1442*n*	9.1478*n*	9.7012	+0.011	+0.002	39 37.93		
	4 Ursæ Minoris B.									
1855	7 3 39.32	1.8979	0.0335*n*	0.0335*n*	0.5785	—0.019	+0.120	89 1 49.52	+0.008	7
1865	16 36.81	1.8833	0.1040*n*	0.1040*n*	0.5633	—0.017	+0.140	0 49.16		
1861		1.8893	0.0781*n*	0.0781*n*	0.5696	—0.018	+0.132			
1862		1.8879	0.0848*n*	0.0848*n*	0.5681	—0.018	+0.134			
1863		1.8864	0.0913*n*	0.0913*n*	0.5665	—0.018	+0.136			
1864		1.8848	0.0977*n*	0.0977*n*	0.5649	—0.017	+0.138			
	156 Camelopardali B.									
1855	7 41 35.85	1.1911	9.4696*n*	9.4716*n*	9.7951	+0.009	—0.005	84 27 38.78	+0.013	6
1865	44 10.61	1.1876	9.4778*n*	9.4799*n*	9.7909	+0.009	—0.005	26 11.81		

* *b* (number) +.1486 for 1855; +.1386 for 1865. Log *c* —Log *b* = +.0016.

† Apparent Places from the *Berliner Astronomisches Jahrbuch.*

‡ *b* (number) —.1880 for 1855; —.2179 for 1865. Log *c* —Log *b* = +.0005.

λ Ursæ Minoris B.

	AR.	log a	log b	log c	log d	μ	ν	Dec.	μ'	Mag.
	h m s					s	s	° ′ ″	″	
1855	20 8 30.70	1.7374n	0.2568	0.2569	0.4590n	—0.073	+0.148	88 52 32.31	+0.015	6.7
1865	19 59 8.86	1.7604n	0.2386	0.2386	0.4808n	—0.077	+0.151	54 15.64		
1861		1.7512n	0.2461	0.2462	0.4721n	—0.075	+0.150			
1862		1.7535n	0.2443	0.2444	0.4743n	—0.076	+0.150			
1863		1.7558n	0.2424	0.2425	0.4765n	—0.076	+0.150			
1864		1.7581n	0.2405	0.2405	0.4786n	—0.077	+0.151			

74 Draconis.

	AR.	log a	log b	log c	log d	μ	ν	Dec.	μ'	Mag.
1855	20 37 38.95	0.4990n	9.4068	9.4127	9.4979n	+0.019	+0.002	80 34 50.70	+0.217	6.7
1865	37 7.40	0.5038n	9.4073	9.4131	9.5004n	+0.019	+0.002	37 0.01		

1 Draconis Hevelii.

	AR.	log a	log b	log c	log d	μ	ν	Dec.	μ'	Mag.
1855	9 16 2.23	0.9676	9.5518n	9.5561n	9.4951	+0.005	+0.004	81 57 38.20	0.000	4.5
1865	17 34.69	0.9638	9.5520n	9.5563n	9.4895	+0.005	+0.004	55 6.36		

30 Camelopardali Hevelii.

	AR.	log a	log b	log c	log d	μ	ν	Dec.	μ'	Mag.
1855	10 12 58.30	0.9133	9.7043n	9.7073n	9.4099	—0.036	+0.005	83 17 32.49	+0.012	5
1865	14 19.36	0.9081	9.7023n	9.7054n	9.4016	—0.036	+0.005	14 33.26		

119 Cephei (Bode).

	AR.	log a	log b	log c	log d	μ	ν	Dec.	μ'	Mag.
1855	21 25 0.23	0.6473n	9.6690	9.6716	9.5761n	+0.010	+0.004	83 38 31.95	—0.016	7
1865	24 15.52	0.6552n	9.6708	9.6735	9.5808n	+0.010	+0.004	41 7.98		

34 Cephei Hevelii.

	AR.	log a	log b	log c	log d	μ	ν	Dec.	μ'	Mag.
1855	22 47 55.06	*	9.6759	9.6797	9.1920n	+0.006	+0.001	82 23 3.30	+0.054	5
1865	47 54.79		9.6790	9.6828	9.1951n	+0.006	+0.001	26 14.56		

202 Camelopardali (Bode).

	AR.	log a	log b	log c	log d	μ	ν	Dec.	μ'	Mag.
1855	11 21 26.20	0.6675	9.6658n	9.6701n	8.9003	—0.047	+0.002	81 55 29.24	+0.022	6
1865	22 12.02	0.6635	9.6631n	9.6675n	8.8887	—0.047	+0.002	52 11.68		

39 Cephei Hevelii.

	AR.	log a	log b	log c	log d	μ	ν	Dec.	μ'	Mag.
1855	23 27 49.30	†	0.0340	0.0349	9.1851n	+0.085	+0.002	86 30 26.61	+0.007	6
1865	27 49.98		0.0410	0.0418	9.1919n	+0.086	+0.002	33 45.27		

309 Cephei (Bode).

	AR.	log a	log b	log c	log d	μ	ν	Dec.	μ'	Mag.
1855	23 52 49.67	0.3959	9.9682	9.9693	8.4649n	+0.035	—0.001	85 53 56.68	—0.019	7
1865	53 15.04	0.4006	9.9742	9.9752	8.4444n	+0.035	—0.001	57 16.96		

* *a* (number) —0s.0215 for 1855 ; —0s.0435 for 1865.
† *a* (number) +0s.0061 for 1855 ; —0s.0418 for 1865.

TABLE V.

	Assumed AR. 1855.		Deviation.			Assumed AR. 1855.		Deviation.	
	h m s					h m s			
12 Ceti,	0 22 38.34	H.			β Arietis,	1 46 38.21	H.		
		Ai.	+39	+56			Ai.	+64	+81
		LeV.					LeV.	+32	+88
		Ai.	+21	+48			Ai.	+51	+78
		1853		+52			1854		+82
		1855		+53			1855		+83
β Ceti,	0 36 18.53	H.	—36	+ 8	67 Ceti,	2 9 45.20	H.		
		Ai.	+28	+45			Ai.	—59	—42
		LeV.	+12	+68			LeV.		
		Ai.	— 4	+23			Ai.	—25	+ 2
		1850		+36			1853		—22
		1855		+38			1855		—22
ε Piscium,	0 55 25.27	H.			ξ² Ceti,	2 20 27.25	H.		
		Ai.	+16	+33			Ai.	+ 2	+19
		LeV.	—80	—24			LeV.	—54	+ 2
		Ai.	—13	+14			Ai.	— 8	+19
		1854		+ 8			1854		+13
		1855		+ 8			1855		+13
θ Ceti,	1 16 46.56	H.	—37	+ 7	γ Ceti,	2 35 47.45	H.	—44	0
		Ai.	+31	+48			Ai.	+20	+37
		LeV.	+10	+66			LeV.	—19	+37
		Ai.	— 8	+19			Ai.	+ 6	+33
		1850		+35			1850		+27
		1855		+37			1855		+28
η Piscium,	1 23 43.82	H.			δ Arietis,	3 3 20.66	H.		
		Ai.	—56	—39			Ai.	+11	+28
		LeV.	—66	—10			LeV.	—45	+11
		Ai.	— 5	+22			Ai.	+11	+38
		1854		— 9			1854		+26
		1855		— 9			1855		+26
ν Piscium,	1 33 53.34 [wt. = ½]	H.			η Tauri,	3 38 52.34	H.	—53	— 9
		Ai.	—21	— 4			Ai.	—22	— 5
		LeV.	+30	+86			LeV.	—73	—17
		Ai.	—25	+ 2			Ai.	+ 4	+31
		1854		+16			1850		0
		1855		+16			1855		0

	Assumed AR. 1855.		Deviation.			Assumed AR. 1855.		Deviation.	
	h m s					h m s			
γ Eridani,	3 51 15.94	H.	—15	+ 29	α Leporis,	5 26 20.20	H.		
		Ai.	+21	+ 38			Ai.	—12	+ 5
	[wt. = ½]	LeV.	+50	+106		[wt. = ½]	LeV.	—57	— 1
		Ai.	— 6	+ 21		[wt. = ½]	Ai.	—55	—28
		1850		+ 40			1853		— 5
		1855		+ 42			1855		— 5
o Eridani,*	4 4 47.37	H.			ε Orionis,	5 28 51.42	H.	— 5	+39
		Ai.	+31	+48			Ai.	+25	+42
		LeV.					LeV.	—13	+43
		Ai.	—15	+12			Ai.	—22	+ 5
		1853		+30			1850		+32
		1855		+31			1855		+34
ε Tauri,	4 20 9.26	H.			ν Orionis,*	5 59 17.56	H.		
		Ai.	+ 4	+21			Ai.		
		LeV.	— 6	50			LeV.	+53	+109
		Ai.	— 2	25			Ai.	+32	+ 59
		1854		+32			1859		+ 84
		1855		+32			1855		+ 81
ι Aurigæ,	4 47 33.42	H.			μ Geminor.	6 14 11.34	H.	—31	+13
		Ai.	—13	+ 4			Ai.	—25	— 8
		LeV.	—91	—35			LeV.	—97	—41
		Ai.	— 7	+20			Ai.	—48	—21
		1854		— 4			1850		—14
		1855		— 4			1855		—15
ε Leporis,*	4 59 19.43	H.			γ Geminor.	6 29 20.15	H.		
		Ai.	+ 7	+24			Ai.	—29	—12
		LeV.					LeV.	—70	—14
		Ai.	0	+27			Ai.	—72	—45
		1853		+25			1854		—24
		1855		+26			1855		—24
δ Orionis,	5 24 36.03	H.	—14	+30	ε Canis Maj.	6 52 55.68	H.		
		Ai.	+ 7	+24			Ai.	+29	+46
		LeV.	—41	+15			LeV.	—16	+40
		Ai.	—19	+ 8			Ai.	0	+27
		1850		+19			1854		+38
		1855		+20			1855		+38

* The Greenwich observations for 1859 – 60, and those made at Paris in 1858 – 59, were included.

	Assumed AR. 1855.		Deviation.	
	h m s			
γ Canis Maj.	6 57 11.92	H.		
		Ai.	+ 9	+26
		LeV.		
		Ai.	+ 2	+29
		1853		+27
		1855		+28
δ Geminorum,	7 11 27.68	H.	− 91	−47
		Ai.	− 54	−37
		LeV.	−152	−96
		Ai.	− 73	−46
		1850		−56
		1855		−59
χ Geminorum, [6 Cancri,]	7 54 36.38	H.		
		Ai.	+86	+103
		LeV.	−96	− 40
		Ai.	+ 5	+ 32
		1853		+ 32
		1855		+ 33
ι Navis, [15 Argus,]	8 1 22.17	H.		
		Ai.	+13	+30
		LeV.	−20	+36
		Ai.	+15	+42
		1854		+36
		1855		+36
η Cancri,	8 24 19.06	H.		
		Ai.	+ 8	+25
		LeV.		
		Ai.	+11	+38
		1853		+31
		1855		+32
ε Hydræ,	8 39 5.66	H.	−31	+13
		Ai.	+14	+31
		LeV.	− 3	+53
		Ai.	− 7	+20
		1850		+29
		1855		+31

	Assumed AR. 1855.		Deviation.	
	h m s			
ι Ursæ Maj.	8 49 15.67	H.	− 66	−22
		Ai.	−100	−83
		LeV.	− 59	− 3
		Ai.	− 45	−18
		1850		−31
		1855		−33
83 Cancri,	9 10 53.01	H.		
		Ai.	−22	− 5
		LeV.		
		Ai.	−22	+ 5
		1853		0
		1855		0
θ Ursæ Maj.	9 23 8.06	H.	−103	−59
		Ai.	− 18	− 1
		LeV.		
		Ai.	− 4	+23
		1848		−12
		1855		−13
ε Leonis,	9 37 36.82	H.	−85	−41
		Ai.	− 9	+ 8
		LeV.	−66	−10
		Ai.	+10	+37
		1850		− 2
		1855		− 2
π Leonis,	9 52 32.88	H.		
		Ai.	−29	−12
		LeV.	− 2	+54
		Ai.	+ 4	+31
		1854		+24
		1855		+24
γ Leonis, preceding,	10 11 58.54*	H.		
		Ai.	−156	−139
		LeV.	−223	−167
		Ai.	−175	−148
		1854		−151
		1855		−152

* The value for the mean of the two stars was used as an assumed AR. The Greenwich observations for 1859 were included.

	Assumed AR. 1855.		Deviation.	
	h m s			
ρ Leonis,	10 25 10.40	H.		
		Ai.	+17	+34
		LeV.	−27	+29
		Ai.	− 6	+21
		1854		+28
		1855		+28
l Leonis,	10 41 37.97	H.		
		Ai.	−25	− 8
		LeV.		
		Ai.	−20	+ 7
		1853		0
		1855		0
χ Leonis,	10 57 32.13	H.		
		Ai.	+ 9	+26
		LeV.	−42	+14
		Ai.	−19	+ 8
		1854		+16
		1855		+16
δ Leonis,	11 6 23.49	H.	+17	+61
		Ai.	+25	+42
		LeV.	−42	+14
		Ai.	+ 3	+30
		1850		+37
		1855		+39
δ Crateris,	11 12 5.63	H.	−13	+31
		Ai.	+51	+68
		LeV.	−24	+32
		Ai.	+21	+48
		1850		+45
		1855		+47
υ Leonis,	11 29 31.51	H.		
		Ai.	+ 6	+23
		LeV.	−28	+28
		Ai.	−12	+15
		1854		+22
		1855		+22

	Assumed AR. 1855.		Deviation.	
	h m s			
ε Corvi,*	12 2 40.41	H.		
		Ai.	−13	+ 4
		LeV.		
		Ai.	+21	+48
		1853		+26
		1855		+26
η Virginis,	12 12 29.29	H.		
		Ai.	− 9	+ 8
		LeV.	+11	+67
		Ai.	+30	+57
		1854		+44
β Corvi,	12 26 46.65	H.		
		Ai.	+69	+86
		LeV.	+24	+80
		Ai.	+48	+75
		1854		+81
		1855		+82
γ Virginis,* [mean of two stars,]	12 34 18.90	H.		
		Ai.		
		LeV.		
		Ai.	−2	+25
		1857		+25
		1855		+25
12 Canum,*	12 49 14.36	H.	−61	−17
		Ai.	−41	−24
		LeV.	−95	−39
		Ai.	−16	+11
		1850		−17
		1855		−18
θ Virginis,*	13 2 26.76	H.		
		Ai.	−17	0
		LeV.	−21	+35
		Ai.	−17	+10
		1854		+15
		1855		+15

* Observations made at Greenwich in 1859 included.

	Assumed AR. 1855.		Deviation.	
	h m s			
ζ Virginis,	13 27 18.44	H.		
		Ai.	+18	+35
		LeV.	—37	+19
		Ai.	+17	+44
		1854		+33
		1855		+33
η Boötis,	13 47 46.84	H.	— 9	+35
		Ai.	+22	+39
		LeV.	—28	+28
		Ai.	+ 2	+29
		1850		+33
		1855		+35
τ Virginis,	13 54 16.20	H.		
		Ai.	—44	—27
		LeV.	—42	+14
		Ai.	—19	+ 8
		1850		— 2
		1855		— 2
ρ Boötis,	14 25 34.87	H.		
		Ai.	—39	—22
		LeV.		
		Ai.	—21	+ 6
		1853		— 8
		1855		— 8
ε Boötis, following,	14 38 39.30	H.	—48	— 4
		Ai.	0	+17
		LeV.	—73	—17
		Ai.	+ 2	+29
		1850		+ 6
		1855		+ 7
ψ Boötis,	14 58 14.02	H.		
		Ai.	+12	+29
		LeV.		
		Ai.	—18	+ 9
		1853		+19
		1855		+19
β Libræ,	15 9 12.58	H.	—52	— 8
		Ai.	—32	—15
		LeV.	—60	— 4
		Ai.	—35	— 8
		1850		— 9
		1855		— 9
β Scorpii,	15 57 0.78	H.	—103	—59
		Ai.	— 79	—62
		LeV.	— 96	—40
		Ai.	— 65	—38
		1850		—50
		1855		—52
δ Ophiuchi,	16 6 45.01	H.	—59	—15
		Ai.	+16	+33
		LeV.	+ 3	+59
		Ai.	+ 1	+28
		1850		+26
		1855		+27
ζ Herculis,	16 35 49.28	H.		
	[wt. = ½]	Ai.	— 41	—24
		LeV.	—121	—65
		Ai.	— 37	—10
		1854		—27
		1855		—27
κ Ophiuchi,	16 50 48.40	H.		
		Ai.	+19	+36
		LeV.	—17	+39
		Ai.	— 4	+23
		1854		+33
		1855		+33
θ Ophiuchi,	17 13 6.49	H.		
		Ai.	—26	— 9
		LeV.	—57	— 1
		Ai.	+10	+37
		1854		+ 9
		1855		+ 9

	Assumed AR. 1855.		Deviation.	
	h m s			
β Draconis,	17 27 9.58	Ai.	— 64	— 47
	[wt. = ½]	H.	— 37	+ 7
	[wt. = ½]	LeV.	—167	—111
		Ai.	+ 4	+ 31
		1850		— 23
		1855		— 24
μ Herculis,	17 40 47.18	H.		
		Ai.	—46	—29
	[wt. = ½]	LeV.	—87	—31
		Ai.	—34	— 7
		1854		—21
		1855		—21
μ^1 Sagittarii,	18 5 5.52	H.		
		Ai.	— 6	+11
		LeV.	+21	+77
		Ai.	+ 5	+32
		1854		+40
		1855		+40
β Lyræ,	18 44 43.65	H.	— 55	—11
		Ai.	— 26	— 9
		LeV.	—106	—50
		Ai.	+ 19	+46
		1850		— 6
		1855		— 6
ζ Aquilæ,	18 58 44.77	H.	—123	—79
		Ai.	— 24	— 7
		LeV.	— 59	— 3
		Ai.	0	+27
		1850		—15
		1855		—16
ω Aquilæ,	19 11 0.63	H.		
		Ai.	—37	—20
	[wt. = ½]	LeV.	—49	+ 7
		Ai.	— 4	+23
		1854		+ 3
		1854		+ 3
	h m s			
δ Aquilæ,	19 18 11.18	H.	— 6	+38
		Ai.	+32	+49
		LeV.	+22	+78
		Ai.	+12	+39
		1850		+51
		1855		+53
h^2 Sagittarii,*	19 27 52.83	H.		
		Ai.		
		LeV.	—59	— 3
		Ai.	—92	—65
		1856		—34
		1855		—34
ϱ Capricorni,	20 20 35.23	H.		
	(4 obs.)	Ai.	—136	—119
	(2 obs.)	LeV.	+ 53	+ 3
	(13 obs.)	Ai.	—105	— 78
		1855		— 78
32 Vulpeculæ,	20 48 22.87	H.		
		Ai.	0	+17
		LeV.	—53	+ 3
		Ai.	+44	+71
		1854		+30
		1855		+31
61 Cygni,	21 0 24.75	H.	—85	—41
[mean of two		Ai.	+ 2	+15
stars,]		LeV.	—28	+28
		Ai.	+66	+93
		1850		+24
		1855		+25
ζ Cygni,	21 6 46.03	H.	—77	—33
		Ai.	—19	— 2
		LeV.	—55	+ 1
		Ai.	— 6	+21
		1850		— 3
		1855		— 3

* Greenwich observations of 1859 included.

	Assumed AR. 1855.		Deviation.			Assumed AR. 1855.		Deviation.	
	h m s					h m s			
β Aquarii,	21 23 55.35	H.	—13	+31	ζ Pegasi,	22 34 13.90	H.	—96	—52
		Ai.	+11	+28			Ai.	—32	—15
		LeV.	0	+56			LeV.	—81	—25
		Ai.	— 8	+19			Ai.	—10	+17
		1850		+34			1850		—19
		1855		+35			1855		—20
ε Pegasi,	21 37 3.85	H.	—23	+21	γ Piscium,	23 9 38.92	H.		
		Ai.	— 9	+ 8			Ai.	+37	+54
		LeV.	—46	+10			LeV.	— 9	+47
		Ai.	+18	+45			Ai.	+15	+42
		1850		+21			1854		+48
		1855		+22			1855		+48
16 Pegasi,	21 46 28.03	H.			κ[1] Piscium,	23 19 29.94	H.		
		Ai.	—41	—24			Ai.	+26	+43
		LeV.					LeV.	+37	+93
		Ai.	—20	+ 7			Ai.	— 3	+24
		1853		— 9			1854		+53
		1855		— 9			1855		+54
θ Aquarii,	22 9 10.75	H.			ι Piscium,	23 32 29.55	H.	+92	+136
		Ai.	— 1	+16			Ai.	+86	+103
		LeV.	—41	+15			LeV.	+13	+ 69
		Ai.	+ 2	+29			Ai.	+29	+ 56
		1854		+20			1850		+ 91
		1855		+20			1855		+ 96
η Aquarii,	22 27 54.24	H.			ω Piscium,	23 51 52.06	H.		
		Ai.	— 2	+15			Ai.	— 3	+14
		LeV.	—19	+37			LeV.	—81	—25
		Ai.	+ 9	+36			Ai.	—41	—14
		1854		+29			1854		— 8
		1855		+30			1855		— 8

NOTE. — The columns headed "Deviation" contain the difference "Observation less Computation," expressed in thousandths of seconds; the numbers in the first of these columns being the direct result from the Catalogues, and those in the second, the same corrected by the quantities on page 547.

TABLE VI.

	AR. 1855.0	Annual Variation.	Secular Variation.		AR. 1855.0	Annual Variation.	Secular Variation.
	h m s	s	s		h m s	s	s
α Andromedæ,	0 0 54.010	+3.08397	+0.01770	ε Leonis,	9 37 36.818	+3.42179	—0.01798
γ Pegasi,	5 46.457	3.08076	+0.00970	π Leonis,	52 32.904	3.17822	—0.00819
12 Ceti,	22 38.393	3.06042	+0.00059	α Leonis,	10 0 38.763	3.20353	—0.01020
β Ceti,	36 18.568	3.01391	—0.00580	γ Leonis, prec.	11 58.388	3.31951	—0.01515
ε Piscium,	55 25.278	3.10944	+0.00852	ϱ Leonis,	25 10.428	3.16739	—0.00817
θ Ceti,	1 16 46.597	+2.99669	+0.00158	l Leonis,	10 41 37.970	+3.16068	—0.00831
η Piscium,	23 43.811	3.19707	+0.01392	χ Leonis,	57 32.146	3.09982	—0.00581
ν Piscium,	33 53.356	3.11423	+0.00893	δ Leonis,	11 6 23.529	3.20499	—0.01354
β Arietis,	46 38.293	3.29597	+0.01809	δ Crateris,	12 5.677	2.99470	+0.00613
α Arietis,	59 0.500	3.36392	+0.02010	υ Leonis,	29 31.532	3.07136	+0.00008
67 Ceti,	2 9 45.178	+2.98604	+0.00479	β Leonis,	11 41 39.669	+3.06661	—0.00770
ξ² Ceti,	20 27.263	3.17892	+0.01153	β Virginis,	43 8.533	3.12472	—0.00060
γ Ceti,	35 47.478	3.10049	+0.00928	ε Corvi,	12 2 40.436	3.07399	+0.01379
α Ceti,	54 42.231	3.12678	+0.00970	η Virginis,	12 29.334	3.06671	+0.00273
δ Arietis,	3 3 20.686	3.41691	+0.01717	β Corvi,	26 46.732	3.13101	+0.01603
η Tauri,	3 38 52.340	+3.55008	+0.01789	γ Virginis, med.	12 34 18.925	+3.03755	+0.00403
γ Eridani,	51 15.982	2.79480	+0.00475	12 Canum Ven.	49 14.342	2.81928	—0.01561
o′ Eridani,	4 4 47.401	2.92074	+0.00600	θ Virginis,	13 2 26.775	3.09894	+0.00758
ε Tauri,	20 9.292	3.49347	+0.01244	α Virginis,	17 33.567	3.14988	+0.01120
α Tauri,	27 36.289	3.43414	+0.01090	ζ Virginis,	27 18.473	3.05219	+0.00611
ι Aurigæ,	4 47 33.416	+3.89371	+0.01523	η Boötis,	13 47 46.875	+2.85875	—0.00066
ε Leporis,	59 19.456	2.53580	+0.00342	τ Virginis,	54 16.198	3.04728	+0.00634
α Aurigæ,	5 5 59.061	4.42031	+0.01840	α Boötis,	14 9 2.949	2.73349	+0.00120
β Orionis,	7 34.294	2.88069	+0.00430	ϱ Boötis,	25 34.862	2.58811	—0.00169
β Tauri,	17 7.747	3.78683	+0.00890	ε Boötis, seq.	38 39.307	2.62017	—0.00005
δ Orionis,	5 24 36.050	+3.06375	+0.00410	α¹ Libræ,	14 42 40.403	+3.30308	+0.01560
α Leporis,	26 20.195	2.64574	+0.00319	α² Libræ,	42 51.833	3.30414	+0.01550
ε Orionis,	28 51.454	3.04138	+0.00381	ψ Boötis,	58 14.039	2.57055	+0.00113
α Orionis,	47 19.409	3.24714	+0.00310	β Libræ,	15 9 12.571	3.21778	+0.01188
ν Orionis,	59 17.641	3.42628	+0.00227	α Coronæ,	28 33.018	2.53833	+0.00240
μ Geminorum,	6 14 11.325	+3.63290	+0.00023	α Serpentis,	15 37 7.734	+2.94935	+0.00630
γ Geminorum,	29 20.126	3.46792	—0.00094	β Scorpii,	57 0.728	3.47595	+0.01455
α Canis Maj.*	38 45.452	2.64508	+0.00040	δ Ophiuchi,	16 6 45.037	3.13560	+0.00846
ε Canis Maj.	52 55.718	2.35827	+0.00164	α Scorpii,	20 31.399	3.66500	+0.01570
γ Canis Maj.	57 11.948	2.71602	+0.00067	ζ Herculis,	35 49.253	2.26165	+0.00319
δ Geminorum,	7 11 27.621	+3.59256	—0.00676	κ Ophiuchi,	16 50 48.433	+2.83429	+0.00458
α Geminorum,†	25 20.245	3.84131	—0.01250	α Herculis,	17 8 2.283	2.73289	+0.00370
α Canis Min.	31 42.628	3.14698	—0.00440	θ Ophiuchi,	13 6.499	3.67702	+0.00871
β Geminorum,	36 26.276	3.68356	—0.01220	α Ophiuchi,	28 12.321	2.78117	+0.00350
χ Geminorum,	54 36.413	3.69912	—0.01429	μ Herculis,	40 47.159	2.34272	+0.00345
ι Navis,	8 1 22.206	+2.55499	+0.00107	μ¹ Sagittarii,	18 5 5.560	+3.58524	+0.00154
η Cancri,	24 19.092	3.48165	—0.01281	α Lyræ,	32 1.781	2.03091	+0.00160
ε Hydræ,	39 5.691	3.18498	—0.00692	β Lyræ,	44 43.644	2.21283	+0.00172
83 Cancri,	9 10 53.010	3.35922	—0.01337	ζ Aquilæ,	58 44.754	2.75318	+0.00061
α Hydræ,	20 27.725	+2.94942	—0.00150	ω Aquilæ,	19 11 0.633	+2.81459	—0.00003

* Peters's correction is yet to be added.

† Mean of the two stars.

	AR. 1855.0	Annual Variation.	Secular Variation.		AR. 1855.0	Annual Variation.	Secular Variation.
	h m s	s	s		h m s	s	s
δ Aquilæ	19 18 11.233	+3.02489	—0.00153	ε Pegasi,	21 37 3.872	+2.94836	—0.00059
h^2 Sagittarii,	27 52.796	3.65940	—0.00965	16 Pegasi,	46 28.021	2.72578	+0.00513
γ Aquilæ,	39 21.991	2.85281	—0.00080	α Aquarii,	58 20.150	3.08414	—0.00430
α Aquilæ,	43 42.531	2.92881	—0.00140	θ Aquarii,	22 9 10.770	3.17178	—0.00771
β Aquilæ,	48 11.470	2.94775	—0.00150	η Aquarii,	27 54.270	3.08381	—0.00324
α^1 Capricorni,	20 9 36.510	+3.33175	—0.00810	ζ Pegasi,	22 34 13.880	+2.98752	+0.00211
α^2 Capricorni,	10 0.414	3.33500	—0.00810	α Piscis Austr.	49 37.775	3.33287	—0.02170
ϱ Capricorni,	20 35.152	3.42960	—0.01118	α Pegasi,	57 32.469	2.98307	+0.00530
α Cygni,	36 29.380	2.04250	+0.00240	γ Piscium,	23 9 38.968	3.10795	+0.00029
32 Vulpeculæ,	48 22.901	2.55446	+0.00264	$\varkappa^1$ Piscium,	19 29.994	3.07564	—0.00021
61 Cygni, med.	21 0 24.775	+2.67784	+0.00392	ι Piscium,	23 32 29.646	+3.08413	+0.00281
ζ Cygni,	6 46.027	2.54826	+0.00384	ω Piscium,	51 52.052	+3.07735	+0.00445
β Aquarii,	23 55.385	3.16430	—0.00711				

TABLE VI. Supplement.

	AR. 1855.0	Annual Variation.	Secular Variation.		AR. 1855.0	Annual Variation.	Secular Variation.
	h m s	s	s		h m s	s	s
α Cassiopeiæ,	0 32 18.284	+3.35312	+0.05440	η Ursæ Maj.	13 41 49.377	+2.37462	—0.01050
α Persei,	3 13 59.591	4.24123	+0.04850	β Ursæ Min.	14 51 10.547	—0.26640	+0.10660
ι Ursæ Maj.	8 49 15.637	4.14858	—0.04433	β Draconis,	17 27 9.556	+1.35102	+0.00545
θ Ursæ Maj.	9 23 8.047	4.06080	—0.05615	γ Draconis,	17 53 14.502	+1.39321	+0.00350
α Ursæ Maj.	10 54 44.415	3.77579	—0.08380	α Cephei,	21 15 6.946	+1.43846	—0.00640
γ Ursæ Maj.	11 46 11.102	+3.19678	—0.04440	β Cephei,	21 26 46.341	+0.80464	—0.03300

NOTES AND ERRATA.

In Table II., λ Ursæ Minoris B., $\Delta\delta'$ (Rob.) *for* —0″.42 *read* —0″.29.
51 Cephei H., *for* Airy, 1845, *read* Airy, 1840, 1839.
for $\Delta\alpha'$ + 7″.67 *read* — 7″.67.
for $\Delta\alpha' \cos\delta'$ + 0.37 *read* —0.37
323 Cephei B., *dele* Airy, 1840.

Table III. is not affected by these errata.

The order of some of the dates in Table II. is reversed in printing: that is, the date for Declination is before that for A.R.

It should perhaps have been stated, that the logarithms a, b, c, d in Table IV. are in the original order of Bessel; the English have arbitrarily changed a, b, c, d to c, d, a, b, and the same inconvenient alteration has been made in the American Ephemeris. Log a is the log of the annual precession in A.R.; μ, μ' are proper motion; ν is $-\frac{1}{2}\frac{d^2 x}{dt^2}$.

In reducing to apparent place for a fraction τ of the year 1865 + n, we interpolate log a, b, c, d for the time 1865 + n + τ, and we shall have (α° being A.R. for 1865),

$$\alpha' - \alpha^\circ = (A + n)\,a + Bb + Cc + Dd + (\tau + n)\,\mu + (\tau + n)^2\,\nu.$$

This includes all the sensible terms except the very small ones depending on ☉ + ☊, ☉ − ☊, if the tables for Log A, B, etc., include them, as do O. Struve's *Tabulæ Quantitatum Besselianarum*.

XX.

The Sun a small Star.

By ALVAN CLARK.

(*Communicated January* 28, 1863.)

Of all the efforts to determine the parallax of stars, both by direct and differential methods, only ten or twelve cases can be cited with any show whatever of success. In α Centauri it amounts to 1″, which is more than double the quantity imputed to either of the others. The conclusion follows, among astronomers, that the stars generally are immensely distant bodies, shining like the Sun with light of their own, and forming a great family of which he is an individual member.

The sum total of light given off by any luminous body can be computed where its distance is known; and it is supposed, from such computation, that several of these stars must considerably exceed the Sun in intrinsic lustre, while 61 Cygni falls below him. Therefore, though classed in one family, inequalities are admitted, and to what extent they may reach among the millions, visible and invisible, we cannot know; but, from all the analogies of nature, we may safely conjecture that the extremes are very great.

If we admit this, and suppose for all the stars in existence a mean equal to our Sun, or even less, those *visible* must possess a mean in brightness much in excess of his; for, by the laws of perspective, the smaller would be lost to our view, at distances from which the brighter might glow, even as first magnitude. This reasoning would apply to telescopic magnitudes as well as to those visible with the naked eye.

Believing this to be true, I have felt a desire to possess some method of making photometrical comparisons between the light received from the Sun and that from a star more reliable than those in common use. If you were to go within the tropics, and sink a well to the depth of several hundred feet, and place yourself at the bottom while an assistant should close the top to produce total obscuration, except one small

hole, in which a lens might be fitted, of the finest material and finish, having a focal distance of the one hundred-thousandth part of the whole distance between your eye and the lens; then by viewing through it the vertical sun, in a clear sky, you would see it reduced exactly as though removed 100,000 times its present distance; and it would barely exceed the brightness of α Lyræ.

From the great number of experiments I have made, I am led to believe this the most reliable method of reducing the Sun's light, for comparing it with any given celestial object. You can free your observation entirely from the distracting effect of daylight, and even an object so bright as the Sun can be reduced by one single plano-convex lens, at one step, to equal a star of the sixth magnitude, if desirable; and when the focal distance of your lens is known, and the distance between your lens and your eye is known, the amount of reduction can be known as readily as you can find how many times the smaller is contained in the larger distance. I have no such well or mine, but a horizontal under-ground chamber 230 feet in length, one end terminating in the cellar of my workshop, and the other communicating with the surface of the ground by a vertical opening one foot square and five feet deep, is a complete equivalent, except that its use involves the necessity of twice reflecting the Sun's light, once by a mirror, and once by a prism of total reflection.

Between the end of the chamber and the vertical opening is a partition with a perforation two inches square, which I can close with plates, containing such lenses as I may wish to use. Within the vertical opening, contiguous to and facing the lens, the prism is placed to receive the Sun's light from the mirror above, and reflect it horizontally through the lens into the chamber.

When a lens one thirty-fourth of an inch in focal distance was employed, on the 24th of November, 1862, the Sun near the meridian and sky remarkably clear, by an observer in the cellar, 230 feet distant, the light received was estimated scarcely equal to that of α Lyræ.

Here the reduction of diameter was only 93,840 times, with the lens and prism very perfect, and cleaned for the occasion.

Three perforations were selected through a strip of thin brass, the largest of which, when held to the eye, should admit light enough for steady visibility; the next, visibility by fits; and the smaller, but little less, producing invisibility.

Three, myself and two sons, took a part in the observation, and with results showing the most perfect equality in our eyes; and when one had been in darkness for fifteen minutes, another fresh from the glare of day, taking his place, would see within two minutes as well, and as well we became satisfied, as we could with any allow-

ance whatever of time and shading. The evening of the 24th of November proved clear and favorable as the day; when the mirror and prism, placed at the same angle, were combined and applied to view α Lyræ, from five to six hours west of the meridian, through the same perforations in the strip of brass.

I suppose the percentage of loss by the prism and mirror would be the same with both objects; so that an allowance for the lens only is to be made; which, according to the best means of judging in my power, would be about ten per cent. Since we found the star and Sun rendered sensibly equal in the above comparisons, it would appear that a removal in space to 103,224 times his present distance would reduce the light of the Sun to an equality with that of the star in question. This is less than half the supposed distance of the nearest star in the whole heavens.

Coupled as this single determination has been with many preliminary experiments and studies, I am prepared to believe that it is very near the truth; though differing largely from the photometrical deductions most generally accredited, and most frequently quoted by astronomical writers. The earth itself, it is supposed, was once a self-luminous body; and there may exist innumerable suns like ours, or even less, within the limits of, and interspaced with, those which decorate a nocturnal sky, and yet remain unknown to man. This, however, would depend much upon the actual diversity existing among them; but that the Maker has chosen variety there, as well as in our more immediate surroundings, I see no reason to doubt. The inequality of such binary stars as ζ Herculis and δ Cygni, which cannot be caused by unequal distances of the components from us, are sufficient to confirm such a conclusion. If we suppose the extremes to be many millions to one, as they are in the planets of our system, and give due weight to the effect of celestial perspective, we could not but expect to find our glorious Sun a small star, if ever adequate means could be devised for demonstrating the true relationship between him and the hosts which are gleaming from such immeasurable distances beyond. The planet Jupiter is sensibly the fourth luminary in the heavens, and yet his four satellites are invisible to the naked eye, though at precisely the same mean distance from us; and further, there exist more than threescore of planets, well known, all of telescopic magnitudes, at distances less than that of Jupiter.

In viewing the Sun reduced 93,840 times, in the dark chamber, I could have stated that it was seen in contrast with a darkness deeper than that of any nocturnal sky, which would favor the supposition that the difference in light between that and α Lyræ might be even less than 10,655,194,176 to 1; but I have no desire to differ more than I feel obliged to do from the teachings of those who have preceded me in this interesting field of research.

The number of stars exhibited in the whole heavens by the more powerful telescopes is not so great, when compared with the smaller instruments and with the naked eye, as theoretically it should be; a fact explained by astronomers, on the supposition that a portion of the light is absorbed or extinguished during its passage through such immense ranges.

Now perhaps a different explanation might be found by assuming such vast differences in the intrinsic brightness of stars, scattered and intermingled through all space, as for aught we know may exist. Near us the small as well as large ones would be seen; but a few billions of miles in depth, at the outer limits of telescopic penetrability, carried over the whole sphere, would furnish room for concealment to hosts of bodies like our Sun, while a few only of very unusual bulk and brightness, interspaced with them, would appear as the faintest discernible points of light, when viewed through the most potent telescope to which the eye of man has ever been applied.

STATUTES

AND

STANDING VOTES

OF THE

AMERICAN ACADEMY OF ARTS AND SCIENCES.

(*Adopted May* 30, 1854: *amended September* 8, 1857, *and November* 12, 1862.)

CHAPTER I.

Of Fellows and Foreign Honorary Members.

1. The Academy consists of *Fellows* and *Foreign Honorary Members.* They are arranged in three classes, according to the Arts and Sciences in which they are severally proficient, viz.: Class I. The Mathematical and Physical Sciences; Class II. The Natural and Physiological Sciences; Class III. The Moral and Political Sciences. Each Class is divided into four Sections, viz.: Class I. Section 1. Mathematics; Section 2. Practical Astronomy and Geodesy; Section 3. Physics and Chemistry; Section 4. Technology and Engineering. Class II. Section 1. Geology, Mineralogy, and Physics of the Globe; Section 2. Botany; Section 3. Zoölogy and Physiology; Section 4. Medicine and Surgery. Class III. Section 1. Philosophy and Jurisprudence; Section 2. Philology and Archæology; Section 3. Political Economy and History; Section 4. Literature and the Fine Arts.

2. Fellows resident in the State of Massachusetts can alone vote at the meetings of the Academy.* They shall each pay to the Treasurer the sum of five dollars on admission, and an annual assessment of two dollars, with such additional sum, not exceeding three dollars, as the Academy shall, by a standing vote, from time to time determine.

3. Fellows residing out of the State of Massachusetts shall be known and distinguished as Associate Fellows. They shall not be liable to the payment of any fees or annual dues, but,

* The number of Resident Fellows is limited by the Charter to 200.

on removing within the State, shall be admitted to the privileges, and be subject to the obligations, of Resident Fellows. The number of Associate Fellows shall not exceed *one hundred*, of whom there shall not be more than *forty* in either of the three classes of the Academy.

4. The number of Foreign Honorary Members shall not exceed *seventy-five;* and they shall be chosen from among persons most eminent in foreign countries for their discoveries and attainments in either of the three departments of knowledge above enumerated. And there shall not be more than thirty Foreign Members in either of these departments.

CHAPTER II.

Of Officers.

1. There shall be a President, a Vice-President, a Corresponding Secretary, a Recording Secretary, a Treasurer, and a Librarian, which officers shall be annually elected, by written votes, at the Annual Meeting, on the day next preceding the last Wednesday in May.

2. At the same time and in the same manner, nine Councillors shall be elected, three from each Class of the Academy, who, with the President, Vice-President, and the two Secretaries, shall constitute a Council for Nomination. It shall also be the duty of this Council to exercise a discreet supervision over all nominations and elections, and to exert their influence to obtain and preserve a due proportion in the number of Fellows and Members in each of the Sections.

3. If any office shall become vacant during the year, the vacancy shall be filled by a new election, and at the next stated meeting.

CHAPTER III.

Of the President.

1. It shall be the duty of the President, and, in his absence, of the Vice-President or next officer in order, as above enumerated, to preside at the meetings of the Academy; to summon extraordinary meetings, upon any urgent occasion; and to execute or see to the execution of the Statutes of the Academy.

2. The President, or, in his absence, the next officer as above enumerated, is empowered to draw upon the Treasurer for such sums of money as the Academy shall direct. Bills presented on account of the Library, or the publications of the Academy, must be previously approved by the respective committees on these departments.

3. The President, or, in his absence, the next officer as above enumerated, shall nominate members to serve on the different committees of the Academy which are not chosen by ballot.

4. Any deed or writing, to which the common seal is to be affixed, shall be signed and sealed by the President, when thereto authorized by the Academy.

CHAPTER IV.

Of Standing Committees.

1. At the Annual Meeting there shall be chosen the following Standing Committees, to serve for the year ensuing, viz.: —

2. The Committee of Finance, to consist of the President, Treasurer, and one Fellow chosen by ballot, who shall have charge of the investment and management of the funds and trusts of the Academy. The general appropriations for the expenditures of the Academy shall be moved by this Committee at the Annual Meeting, and all special appropriations from the general and publication funds shall be referred to or proposed by this Committee.

3. The Rumford Committee, of seven Fellows, to be chosen by ballot, who shall consider and report on all applications and claims for the Rumford Premium, also on all appropriations from the income of the Rumford Fund, and generally see to the due and proper execution of this trust.

4. The Committee of Publication, of three Fellows, to whom all memoirs submitted to the Academy shall be referred, and to whom the printing of memoirs accepted for publication shall be intrusted.

5. The Committee on the Library, of three Fellows, who shall examine the Library, and make an annual report on its condition and management.

6. An Auditing Committee, of two Fellows, for auditing the accounts of the Treasurer.

CHAPTER V.

Of the Secretaries.

1. The Corresponding Secretary shall conduct the correspondence of the Academy, recording or making an entry of all letters written in its name, and preserving on file all letters which are

received; and at each meeting he shall present the letters which have been addressed to the Academy since the last meeting. With the advice and consent of the President, he may effect exchanges with other scientific associations, and also distribute copies of the publications of the Academy among the Associate Fellows and Foreign Honorary Members, as shall be deemed expedient; making a report of his proceedings at the Annual Meeting. Under the direction of the Council for Nomination, he shall keep a list of the Fellows, Associate Fellows, and Foreign Honorary Members, arranged in their Classes and in Sections in respect to the special sciences in which they are severally proficient; and he shall act as secretary to the Council.

2. The Recording Secretary shall have charge of the Charter and statute-book, journals, and all literary papers belonging to the Academy. He shall record the proceedings of the Academy at its meetings; and after each meeting is duly opened, he shall read the record of the preceding meeting. He shall notify the meetings of the Academy, and apprise committees of their appointment. He shall post up in the Hall a list of the persons nominated for election into the Academy; and when any individual is chosen, he shall insert in the record the names of the Fellows by whom he was nominated.

3. The two Secretaries, with the Chairman of the Committee of Publication, shall have authority to publish such of the proceedings of the Academy as may seem to them calculated to promote the interests of science.

CHAPTER VI.

Of the Treasurer.

1. The Treasurer shall give such security for the trust reposed in him as the Academy shall require.

2. He shall receive officially all moneys due or payable, and all bequests or donations made to the Academy, and by order of the President or presiding officer shall pay such sums as the Academy may direct. He shall keep an account of all receipts and expenditures; shall submit his accounts to the Auditing Committee; and shall report the same at the expiration of his term of office.

3. The Treasurer shall keep a separate account of the income and appropriation of the Rumford Fund, and report the same annually.

4. All moneys which there shall not be present occasion to expend shall be invested by the Treasurer, under the direction of the Finance Committee, on such securities as the Academy shall direct.

5. The Treasurer shall have the power, with the consent of the Committee of Finance, to remit the admission fee of five dollars, and likewise any annual assessment above the sum of two dollars, in all such cases as he shall deem reasonable and proper.

CHAPTER VII.

Of the Librarian and Library.

1. It shall be the duty of the Librarian to take charge of the books, to keep a correct catalogue of the same, and to provide for the delivery of books from the Library. He shall also have the custody of the publications of the Academy.

2. The Librarian, in conjunction with the Committee on the Library, shall have authority to expend, as they may deem expedient, such sums as may be appropriated, either from the Rumford or the General Fund of the Academy, for the purchase of books and for defraying other necessary expenses connected with the Library. They shall have authority to propose rules and regulations concerning the circulation, return, and safe-keeping of books; and to appoint such agents for these purposes as they may think necessary.

3. To all books in the Library procured from the income of the Rumford Fund, the Librarian shall cause a stamp or label to be affixed, expressing the fact that they were so procured.

4. Every person who takes a book from the Library shall give a receipt for the same to the Librarian or his assistant.

5. Every book shall be returned in good order, regard being had to the necessary wear of the book with good usage. And if any book shall be lost or injured, the person to whom it stands charged shall replace it by a new volume or set, if it belong to a set, or pay the current price of the volume or set to the Librarian; and thereupon the remainder of the set, if the volume belonged to a set, shall be delivered to the person so paying for the same.

6. All books shall be returned to the Library for examination, at least one week before the Annual Meeting.

CHAPTER VIII.

Of Meetings.

1. There shall be annually four stated meetings of the Academy; namely, on the day next preceding the last Wednesday in May (the Annual Meeting), on the second Wednesday in August, on the second Wednesday in November, and on the last Wednesday in January; to

be held in the Hall of the Academy, in Boston. At these meetings only, or at meetings adjourned from these and regularly notified, shall appropriations of money be made, or alterations of the statutes or standing votes of the Academy be effected.

2. Fifteen Fellows shall constitute a quorum for the transaction of business at a stated meeting. Seven Fellows shall be sufficient to constitute a meeting for scientific communications and discussions.

3. The Recording Secretary shall notify the meetings of the Academy to each Fellow residing in Boston and the vicinity; and he may cause the meetings to be advertised, whenever he deems such further notice to be needful.

CHAPTER IX.

Of the Election of Fellows and Honorary Members.

1. Elections shall be made by ballot, and only at the stated meetings in May, November, and January.

2. Candidates for election as Resident Fellows must be proposed by two or more Resident Fellows, in a recommendation signed by them, specifying the Section to which the nomination is made; which recommendation shall be read at a stated meeting, and then stand on the nomination list during the interval between two stated meetings, and until the balloting. No person shall be elected a Resident Fellow, unless he shall have been resident in this Commonwealth one year next preceding his election; and any Resident Fellow, hereafter elected, who shall reside out of the Commonwealth for the term of five years, and shall discontinue the payment of his assessments during that time, shall be deemed to have abandoned his fellowship; provided, nevertheless, that this abandonment of fellowship for non-residence shall not apply to persons engaged in the service of the State, or of the United States.

3. The nomination of Associate Fellows shall take place in the manner prescribed in reference to Resident Fellows; and after such nomination shall have been publicly read at a stated meeting previous to that when the balloting takes place, it shall be referred to a Council for Nomination; and a written approval, authorized and signed at a meeting of said Council by at least seven of its members, shall be requisite to entitle the candidate to be balloted for. The Council may in like manner originate nominations of Associate Fellows; which must be read at a stated meeting previous to the election, and be exposed on the nomination list during the interval.

4. Foreign Honorary Members shall be chosen only after a nomination made at a meeting of the Council, signed at the time by at least seven of its members, and read at a stated meeting previous to that on which the balloting takes place.

5. Three fourths of the ballots cast must be affirmative, and the number of affirmative ballots must amount to eleven, to effect an election of Fellows or Foreign Honorary Members.

6. Each section of the Academy is empowered to present lists of persons deemed best qualified to fill vacancies occurring in the number of Foreign Honorary Members or Associate Fellows allotted to it; and such lists, after being read at a stated meeting, shall be referred to the Council for Nomination.

CHAPTER X.

Of Amendments of the Statutes.

1. All proposed alterations of the statutes, or additions to them, shall be referred to a committee during the interval between two stated meetings, and shall require for enactment a majority of two thirds of the members present, and at least eighteen affirmative votes.

2. Standing Votes may be passed, amended, or rescinded, at any stated meeting, by a majority of two thirds of the members present. They may be suspended by a unanimous vote.

CHAPTER XI.

Of Literary Performances.

1. The Academy will not express its judgment on literary or scientific memoirs or performances submitted to it, or included in its publications.

STANDING VOTES.

1. Communications of which notice has been given to the Secretary shall take precedence of those not so notified.

2. Resident Fellows who have paid all fees and dues chargeable to them are entitled to receive one copy of each volume or article printed by the Academy, on application to the Librarian personally or by written order, within two years from the date of publication.

3. Resident Fellows may borrow and have out from the Library six volumes at any one time, and may retain the same for three months, and no longer.

4. Upon special application, and for adequate reasons assigned, the Librarian may permit a larger number of volumes, not exceeding twelve, to be drawn from the Library, for a limited period.

5. Works published in numbers, when unbound, shall not be taken from the Hall of the Academy, except by special leave of the Librarian.

6. Books, publications, or apparatus shall be procured from the income of the Rumford Fund only on the certificate of the Rumford Committee, that they, in their opinion, will best facilitate and encourage the making of discoveries and improvements which may merit the Rumford Premium.

7. The annual assessment upon Resident Fellows shall be five dollars, until otherwise ordered.

8. The annual meeting shall be holden at half past three o'clock, P. M. The other stated meetings at half past seven o'clock, P. M.

9. A meeting for receiving and discussing scientific communications shall be held on the second Tuesday of each month, excepting the three summer months.

RUMFORD PREMIUM.

In conformity with the last will of Benjamin Count Rumford, granting a certain fund to the American Academy of Arts and Sciences, and with a decree of the Supreme Judicial Court for carrying into effect the general charitable intent and purpose of Count Rumford, as expressed in his said will, the Academy is empowered to make from the income of said fund, as it now exists, at any annual meeting, an award of a gold and silver medal, being together of the intrinsic value of three hundred dollars, as a premium, to the author of any important discovery or useful improvement in light or in heat, which shall have been made and published by printing, or in any way made known to the public, in any part of the continent of America, or any of the American islands; preference being always given to such discoveries as shall, in the opinion of the Academy, tend most to promote the good of mankind; and to add to such medals, as a further premium for such discovery and improvement, if the Academy see fit so to do, a sum of money not exceeding three hundred dollars.

LIST

OF THE

AMERICAN ACADEMY OF ARTS AND SCIENCES.

MAY 1, 1863.

FELLOWS.

CLASS I. — *Mathematical and Physical Sciences.*

Section I.

Mathematics.

William P. G. Bartlett,	Cambridge.
Ezekiel B. Elliott,	Boston.
William Ferrel,	Cambridge.
Benjamin A. Gould,	Cambridge.
John B. Henck,	Dedham.
Thomas Hill,	Cambridge.
Simon Newcomb,	Newport.
James E. Oliver,	Lynn.
Benjamin Peirce,	Cambridge.
James M. Peirce,	Cambridge.
John D. Runkle,	Cambridge.
Truman H. Safford,	Cambridge.
Thomas Sherwin,	Boston.
Chauncey Wright,	Cambridge.
Joseph Winlock,	Cambridge.

Section II.

Practical Astronomy and Geodesy.

George P. Bond,	Cambridge.
J. Ingersoll Bowditch,	Boston.
Alvan Clark,	Cambridge.
Charles Henry Davis,	Cambridge.
William Mitchell,	Lynn.
Maria Mitchell,	Lynn.
Robert Treat Paine,	Boston.
C. H. F. Peters,	Clinton, N. Y.
George Searle,	Brookline.

Section III.

Physics and Chemistry.

Joseph Hale Abbot,	Beverly.
John Bacon, Jr.,	Boston.

John H. Blake,	Boston.
William F. Channing,	Boston.
Thomas Edward Clark,	Williamstown.
Josiah P. Cooke,	Cambridge.
William P. Dexter,	Boston.
Charles W. Eliot,	Cambridge.
Moses G. Farmer,	Boston.
Augustus A. Hayes,	Boston.
Albert Hopkins,	Williamstown.
Eben N. Horsford,	Cambridge.
Joseph Lovering,	Cambridge.
Francis Peabody,	Salem.
E. S. Ritchie,	Boston.
Frank H. Storer,	Boston.
Cyrus M. Warren,	Boston.

Section IV.

Technology and Engineering.

Henry L. Abbot,	Cambridge.
Edward C. Cabot,	Boston.
Henry L. Eustis,	Cambridge.
James B. Francis,	Lowell.
James Hayward,	Boston.
Charles Jackson,	Boston.
John C. Lee,	Salem.
William R. Lee,	Boston.
Charles S. Storrow,	Lawrence.
William H. Swift,	Boston.
John H. Temple,	Boston.
Daniel Treadwell,	Cambridge.
Morrill Wyman,	Cambridge.

CLASS II. — *Natural and Physiological Sciences.*

Section I.

Geology, Mineralogy, and Physics of the Globe.

Francis Alger,	South Boston.
Thomas T. Bouvé,	Boston.
Edward Hitchcock,	Amherst.
Jonathan P. Hall,	Boston.
Charles T. Jackson,	Boston.
Jules Marcou,	Cambridge.
Henry D. Rogers,	Boston.
William B. Rogers,	Boston.
Charles U. Shepard,	Amherst.
Josiah D. Whitney,	Northampton.

Section II.

Botany.

Jacob Bigelow,	Boston.
George B. Emerson,	Boston.
Asa Gray,	Cambridge.
John A. Lowell,	Boston.
John L. Russell,	Salem.
Charles James Sprague,	Boston.
Edward Tuckerman,	Amherst.

Section III.

Zoölogy and Physiology.

Alexander E. R. Agassiz,	Cambridge.
Louis Agassiz,	Cambridge.
Thomas M. Brewer,	Boston.
Henry Bryant,	Boston.
John Dean,	Boston.
Samuel Cabot, Jr.,	Boston.
Henry James Clark,	Cambridge.
Silas Durkee,	Boston.
Augustus A. Gould,	Boston.

Samuel Kneeland, Jr.,	Boston.
Theodore Lyman,	Brookline.
Charles Pickering,	Boston.
D. Humphreys Storer,	Boston.
David Weinland,	Cambridge.
Henry Wheatland,	Salem.
Jeffries Wyman,	Cambridge.

Section IV.

Medicine and Surgery.

Samuel L. Abbot,	Boston.
Henry J. Bigelow,	Boston.
Henry I. Bowditch,	Boston.
Benjamin E. Cotting,	Roxbury.
Calvin Ellis,	Boston.
George Hayward,	Boston.
Oliver W. Holmes,	Boston.
James Jackson,	Boston.
John B. S. Jackson,	Boston.
Henry C. Perkins,	Newburyport.
Charles G. Putnam,	Boston.
Edward Reynolds,	Boston.
Horatio R. Storer,	Boston.
Charles E. Ware,	Boston.
John Ware,	Boston.
John M. Warren,	Boston.

CLASS III. — *Moral and Political Sciences.*

Section I.

Philosophy and Jurisprudence.

William Allen,	Northampton.
George T. Bigelow,	Boston.
Francis Bowen,	Cambridge.
John Henry Clifford,	New Bedford.
Benjamin R. Curtis,	Boston.
Mark Hopkins,	Williamstown.
Charles G. Loring,	Boston.
Joel Parker,	Cambridge.
Theophilus Parsons,	Cambridge.
George Putnam,	Roxbury.
William A. Stearns,	Amherst.
Benjamin F. Thomas,	Boston.
James Walker,	Cambridge.
Emory Washburn,	Cambridge.

Section II.

Philology and Archæology.

Ezra Abbot,	Cambridge.
Albert N. Arnold,	Westborough.
Charles Beck,	Cambridge.
Epes S. Dixwell,	Cambridge.
Charles Folsom,	Cambridge.
William W. Goodwin,	Cambridge.
Ephraim W. Gurney,	Cambridge.
Horatio B. Hackett,	Newton.
William Jenks,	Boston.
George M. Lane,	Cambridge.
George Livermore,	Cambridge.
George R. Noyes,	Cambridge.
Chandler Robbins,	Boston.
James Savage,	Boston.

Nathaniel B. Shurtleff,	Boston.
Evangelinus A. Sophocles,	Cambridge.
Samuel Swett,	Boston.
Joseph E. Worcester,	Cambridge.

Section III.

Political Economy and History.

Caleb Cushing,	Newburyport.
George E. Ellis,	Boston.
Edward Everett,	Boston.
Levi Lincoln,	Worcester.
J. L. Motley,	Boston.
Francis Parkman,	Boston.
Willard Phillips,	Cambridge.
Josiah Quincy,	Boston.
John Reed,	Bridgewater.
Jared Sparks,	Cambridge.
Henry W. Torrey,	Cambridge.
Robert C. Winthrop,	Boston.

Section IV.

Literature and the Fine Arts.

Charles F. Adams,	Boston.
William T. Andrews,	Boston.
George S. Boutwell,	Groton.
Francis J. Child,	Cambridge.
John B. Fitzpatrick,	Boston.
Nathaniel L. Frothingham,	Boston.
John C. Gray,	Boston.
Richard Greenough,	Boston.
Charles C. Jewett,	Boston.
Henry W. Longfellow,	Cambridge.
Francis C. Lowell,	Boston.
James Russell Lowell,	Cambridge.
Charles E. Norton,	Cambridge.
Octavius Pickering,	Boston.
William W. Story,	Boston.
George Ticknor,	Boston.
Edward Wigglesworth,	Boston.

ASSOCIATE FELLOWS.

CLASS I. — *Mathematical and Physical Sciences.*

Section I.

Mathematics.

Charles Avery,	Clinton, N. Y.
Alexis Caswell,	Providence, R. I.
William Chauvenet,	St. Louis, Mo.
Charles Davies,	New York.
Jeremiah Day,	New Haven, Conn.
Charles Gill,	Flushing, N. Y.
J. S. Hubbard,	Washington, D. C.
Hubert A. Newton,	New Haven, Conn.
William Smyth,	Brunswick, Maine.
Theodore Strong,	New Brunswick, N. J.

Section II.

Practical Astronomy and Geodesy.

Stephen Alexander,	Princeton, N. J.
Alexander D. Bache,	Washington, D. C.
W. H. C. Bartlett,	West Point, N. Y.
J. H. C. Coffin,	Newport, R. I.
William H. Emory,	Washington, D. C.
J. M. Gilliss,	Washington, D. C.
James D. Graham,	Washington, D. C.
Elias Loomis,	New York.
Charles Wilkes,	Washington, D. C.

Section III.

Physics and Chemistry.

A. P. Barnard,	Oxford, Miss.
Wolcott Gibbs,	New York.
Joseph Henry,	Washington, D. C.
E. B. Hunt,	New York.
T. Sterry Hunt,	Montreal, Canada.
John L. LeConte,	Columbia, S. C.
W. A. Norton,	New Haven, Conn.
Charles G. Page,	Washington, D. C.
Benjamin Silliman,	New Haven, Conn.
Benjamin Silliman, Jr.,	New Haven, Conn.

Section IV.

Technology and Engineering.

J. J. Abert,	Washington, D. C.
Richard Delafield,	Washington, D. C.
A. A. Humphreys,	Washington, D. C.
Dennis H. Mahan,	West Point, N. Y.
S. F. B. Morse,	Poughkeepsie, N. Y.
Sylvanus Thayer,	New York.
Joseph G. Totten,	Washington, D. C.

CLASS II. — *Natural and Physiological Sciences.*

Section I.

Geology, Mineralogy, and Physics of the Globe.

Charles Cramer,	St. Petersburg.
James D. Dana,	New Haven, Conn.
J. W. Dawson,	Montreal, Canada.
Edward Desor,	Neufchatel.
John C. Fremont,	Mariposa, California.
Arnold Guyot,	Princeton, N. J.
James Hall,	Albany, N. Y.
F. S. Holmes,	Charleston, S. C.
Sir William E. Logan,	Montreal, Canada.
George E. Swallow,	Columbia, Missouri.

Section II.

Botany.

Francis Boott,	London.
Moses A. Curtis,	Hillsboro, N. C.
Chester Dewey,	Rochester, N. Y.
George Engelmann,	St. Louis, Mo.
William S. Sullivant,	Columbus, Ohio.
John Torrey,	New York.

Section III.

Zoölogy and Physiology.

John Bachman,	Charleston, S. C.
Spencer F. Baird,	Washington, D. C.
John C. Dalton, Jr.,	New York.
S. Stehman Haldeman,	Columbia, Pa.
John E. Holbrook,	Charleston, S. C.
J. P. Kirtland,	Cleveland, Ohio.
John L. LeConte,	Philadelphia.
Joseph Leidy,	Philadelphia.
St. Julien Ravenel,	Charleston, S. C.

Section IV.

Medicine and Surgery.

Isaac Hays,	Philadelphia.
Reuben D. Mussey,	Cleveland, Ohio.
Joseph Roby,	Baltimore, Md.
William Sweetser,	Burlington, Vt.
George B. Wood,	Philadelphia.

CLASS III. — *Moral and Political Sciences.*

Section I.

Philosophy and Jurisprudence.

Laurens P. Hickok,	Schenectady, N. Y.
Alonzo Potter,	Philadelphia, Pa.
Francis Wayland,	Providence, R. I.

Section II.

Philology and Archæology.

S. P. Andrews,	New York.
James Hadley, Jr.,	New Haven, Conn.
George P. Marsh,	Burlington, Vt.
Alpheus S. Packard,	Brunswick, Maine.
Edward Salisbury,	New Haven, Conn.
William D. Whitney,	New Haven, Conn.
Theodore D. Wolsey,	New Haven, Conn.

Section III.

Political Economy and History.

Francis Lieber,	New York.
Samuel Greene Arnold,	Providence, R. I.

Section IV.

Literature and the Fine Arts.

William C. Bryant,	New York.
Joseph G. Cogswell,	New York.
Hiram Powers,	Florence.

FOREIGN HONORARY MEMBERS.

CLASS I. — *Mathematical and Physical Sciences.*

Section I.

Mathematics.

John C. Adams,	Cambridge.
George B. Airy,	Greenwich.
Sir William R. Hamilton,	Dublin.
Hansen,	Seeberg.
Le Verrier,	Paris.
Liouville,	Paris.
Sir John W. Lubbock,	London.
Ostrogradsky,	St. Petersburg.
Plana,	Turin.

Section II.

Practical Astronomy and Geodesy.

Argelander,	Bonn.
Encke,	Berlin.
Sir John F.W. Herschel, Bart.,	London.
Peters,	St. Petersburg.
William H. Smyth,	London.
Struve,	St. Petersburg.

Section III.

Physics and Chemistry.

Sir David Brewster,	Edinburgh.
Dumas,	Paris.
Michael Faraday,	London.
Christopher Hansteen,	Christiania.
Liebig,	Munich,
Mitscherlich,	Berlin.
Regnault,	Paris.
Heinrich Rose,	Berlin.

Section IV.

Technology and Engineering.

Charles Babbage,	London.
Sir William Fairbairn,	Manchester.
Fourneyron,	Paris.

CLASS II. — *Natural and Physiological Sciences.*

Section I.

Geology, Mineralogy, and Physics of the Globe.

Elie de Beaumont,	Paris.
Duperrey,	Paris.
Dove,	Berlin.
Sir Charles Lyell,	London.
Sir Roderick I. Murchison,	London.
Quételet,	Brussels.
Adam Sedgwick,	Cambridge.
De Verneuil,	Paris.

SECTION II.

Botany.

Decaisne,	Paris.
DeCandolle,	Geneva.
Elias Fries,	Lund.
Sir William J. Hooker,	Kew.
John Lindley,	London.
Martius,	Munich.
Mohl,	Tübingen.

SECTION III.

Zoölogy and Physiology.

Karl E. von Baer,	St. Petersburg.
Theodor L. W. Bischoff,	Giessen.
Ehrenberg,	Berlin.
Milne-Edwards,	Paris.
Albrecht Kölliker,	Wurtzburg.
Richard Owen,	London.
C. Th. von Siebold.	Munich.
Valentin,	Berne.

SECTION IV.

Medicine and Surgery.

Andral,	Paris.
Louis,	Paris.
Rayer,	Paris.
Rokitansky,	Vienna.

CLASS III. — *Moral and Political Sciences.*

SECTION I.

Philosophy and Jurisprudence.

Cousin,	Paris.
Mittermaier,	Heidelberg.
Trendelenburg,	Berlin.
Archbishop Whately,	Dublin.
William Whewell,	Cambridge.

SECTION II.

Philology and Archæology.

Bekker,	Berlin.
Boeckh,	Berlin.
Bopp,	Berlin.
Eyriès,	Paris.
Pascual de Gayangos,	Madrid.
Grimm,	Berlin.
Lepsius,	Berlin.
Duke di Serradifalco,	Palermo.

SECTION III.

Political Economy and History.

Guizot,	London.
George Grote,	London.
John Stuart Mill,	London.
Leopold von Ranke,	Berlin.

SECTION IV.

Literature and the Fine Arts.

Gino Capponi,	Italy.
Joaquim J. da Costa de Macedo,	Lisbon.